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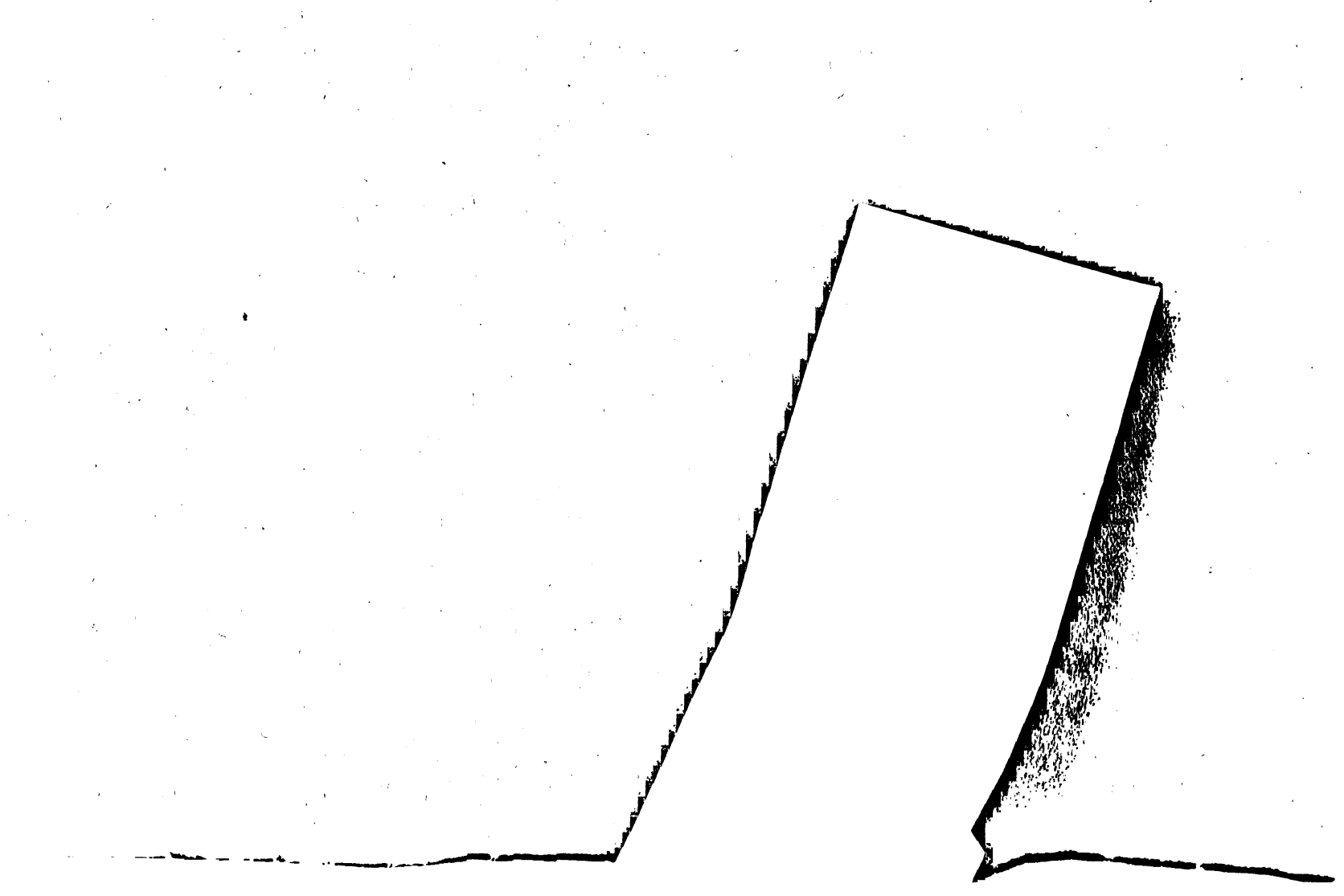

REPORT

TO THE

Director of Public Service

AKRON, OHIO

ON

SEWAGE TREATMENT

AND

TRADE WASTES

BY

HARRY B. HOMMON

OCTOBER 10, 1912

AKRON, OHIO.

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General Plan of Testing Station ..... Insert, following Appendix K

Akron, Ohio, October 10, 1912.

Robert M. Pillmore, Director,
Department of Public Service,
Akron, Ohio.

Dear Sir:

Herewith is submitted a final report regarding operations at the Akron Sewage Testing Station including the results of critical studies of the local sewage disposal problem and of the allied subjects of industrial wastes and sewer air. For the sake of clearness, it seems desirable to outline a few general facts regarding the City of Akron, existing sewer facilities, and conditions which gave rise to the operation of a sewage testing station.

The City of Akron, the County Seat of Summit County, lies on both sides of the valley of the Little Cuyahoga River, about one mile above its confluence with the main stream of the Cuyahoga River. According to the Census of 1910, the population of Akron was 69,067. It is now estimated at 75,000. The city is an active industrial center with a marked diversity of industries, chief of which are rubber, sewer pipe and cereal. Water supply conditions of Akron are well understood at this time, and it is merely necessary to recall here that the average daily water consumption for 1910 was 7,340,000 gallons per day. The report of Messrs. Barbour and Bradbury shows marked leakages which have a bearing upon the character of the Akron sewage.

The sewerage system of Akron is largely upon the separate plan and has a total length of about 100 miles. As shown in the appendix, only the central district is sewered on the combined plan. On account of defective sewer joints, largely attributable to unfavorable soil conditions, and the practice of connecting downspouts to the house sewers, the ground water flowage is high, and during storms the flow of sewage is greatly increased. As a result of the latter condition, there are numererous overflows into the canal and into the river. The main outlet of the Akron sewer system is 42 inches in diameter and empties into the Little Cuyahoga River at a point about 500 feet below Lock 16 of the Ohio Canal.

According to the records of the U. S. Geological Survey covering the years 1903 to 1906 inclusive, the extreme dry weather flow of the Cuyahoga River at Independence, below Akron, is about 56 sec. feet, or 36,000,000 gallons in 24 hours. During such dry periods, on the basis of a required dilution of 5 cu. ft. per sec. per 1,000 people, the flow of the river would be sufficient to satisfactorily dilute the sewage of about 11,000 population, or roughly 15 per cent. of the present population of the city.

REASONS FOR TESTS

In the fall of 1910, brought about largely by law suits on the part of riparian owners on the Cuyahoga River below Akron, the city took initial steps to provide more adequate means for the disposal of the Akron sewage, and engaged Mr. E. G. Bradbury to advise regarding the most practical and economical means for solving the sewage disposal problem of greater Akron. For reasons elaborated below, in a preliminary report submitted by Mr. Bradbury in December, 1910, it was advised that prior to final decision regarding

design, there be instituted a series of tests bearing upon the applicability of current sewage treatment procedures to the supposed unusual nature of the local sewage, to study particularly the suitability of locally available filtering material and to determine the somewhat remote possibility of utilizing dilution facilities in the Cuyahoga River from the point of view of the but partial treatment of Akron sewage, all features closely related to marked economy in first cost, to efficiency and to ease of operation at the contemplated sewage disposal works.

As stated in Mr. Bradbury's report, the purpose of the Akron tests was as follows:

"1. To determine whether trade wastes can be best handled with the sewage or independently.

"2. To select the most efficient and economical processes of preliminary and final treatment with the optimum routine and rates of operation of the same.

"3. To study the sludge problem and devise the best means for its solution.

"4. To investigate the diluting capacity of the river with reference to sewage in various stages of purification.

"5. To determine the suitability of local material as filtering media.

"6. To discover, if possible, a means of prevention of aerial nuisance arising from the using of sprinkling filters."

In carrying out the studies of the testing station, there has rigidly been kept in mind the viewpoint that the devices under test and the results of all studies and tests should be interpreted with reference to the peculiar features of the Akron sewage problem. In other words, stress has been laid upon the only features which have a bearing upon a decision as to the economical details of sewage purification works for Greater Akron. On this account, and also in view of the limited time available for these tests, there have been developed fewer data of general interest than would be true had the tests been more elaborate and of longer duration.

BRIEF DESCRIPTION OF STATION

The station and devices under study may briefly be described as follows:

The equipment comprised a gas engine driven centrifugal pump deriving sewage from the 42 inch outfall sewer, a 4 inch iron force main 240 feet long, a laboratory building specially equipped for sewage tests and the following devices for testing the treatment of the local sewage: A grit chamber, Imhoff tank, Dortmund tank, septic tank, three sprinkling filters and settling basins, two contact filters and a sludge tank. In addition to tests upon these devices, special studies were made regarding industrial wastes, and the composition of sewer air and gases in the Akron trunk sewer.

STARTING OF OPERATIONS

Construction of the Akron Sewage Testing Station was begun on November 5, 1911, and, with the exception of the filters and settling basins, was completed on December 26, 1911. The station was started in operation on January 1; Filter No. 1 was placed in service on April 13, and Filters Nos. 2 and 3 on May 26. The two contact filters were started on June 13, 1912.

WEATHER CONDITIONS DURING TESTS

The climatological data for the period covered by the tests were obtained through the courtesy of Prof. C. R. Olin of Buchtel College. Average weather conditions are shown by the data in the following table:

Climatological Data for Period Covered by Tests

Month 1912	Temperature Deg. F. Max.	Min.	Average	Rainfall (inches)	Snowfall (inches)
January	50	-12.5	16	1.75	11.3
February	55	- 5.5	21	1.54	8.5
March	61	8	29	2.79	3.7
April	70	26	50	5.60	0.0
May	88	34	62	2.62	0.0
June	88	36	66	3.07	0.0
July	89	51	72	5.55	0.0
August	88	47	66	2.71	0.0
September	92	57	77	.30	0.0 Until Sept. 11

EXTENT OF ANALYTICAL WORK

The average daily volume of sewage pumped to the station during the tests was about 50,000 gallons. Of the crude sewage and of the effluents from the different test devices, there were collected frequent samples in accordance with a sampling and operating schedule described in the main body of the report. The extent of the anlytical work may be noted from the following report of the analyses: Crude Sewage, 104; Preparatory Treatments, 312; Sprinkling Filters and Settling Basins, 135; Contact Filters, 12; Industrial Wastes, 28; Analyses of Sewer Air, 15, and 24 Analyses of Sludge. In addition to the above, there were made numerous observations of an engineering nature and many other studies bearing upon the general sewage problem of Akron.

In connection with the development of a new water supply for the city, there were made about 100 analyses of water, numerous field observations, special studies and tests.

PERSONNEL OF STAFF

The testing station was in charge of the writer, assisted by the following: G. E. Flower, Assistant Chemist; Thomas Dunckley, Fred Gauthier and Vincent Tobin, Inspectors. Otto Symes and Charles Criss were employed a short time as Inspectors in collecting samples of manufactural wastes.

ACKNOWLEDGMENTS

It is desired to acknowledge the conscientious work of Mr. Flower, and the faithful services of the several Inspectors, to whose efforts is largely attributable the accuracy of the observations and the reliability of the data obtained during this investigaion.

Many valuable suggesions were made, and much assistance was received from Mr. E. G. Bradbury.

It is especially desired to acknowledge assistance rendered by the former Director of Public Service, Mr. John Gauthier, under whose administration the work was started, and also the hearty co-operation of the present Director of Public Service, Mr. Robert M. Pillmore, and that of the other city officials.

COST OF TESTS

The total cost of the investigations to date is about $9,500.00. The station has been completely dismantled and the apparatus and chemicals have been turned over to the city laboratory. The value of this equipment is estimated at $300.00.

GENERAL CHARACTER OF THE REPORT

The main text of the report deals with the general conduct of the tests and the conclusions drawn from the data collected. Certain features of general interest with respect to the Akron sewage problem and details of analyses are submitted as appendices. The subjects discussed in this report in order are:

1. Composition of Akron Sewage.
2. Description of Testing Station.
3. Preparatory Treatment.
4. Sprinkling Filters.
5. Contact Filters.
6. Analyses of Sewer Air.
7. General Summary and Conclusions.
8. Appendices.

COMPOSITION OF AKRON SEWAGE

The testing station was located a short distance from the outlet of the 42-inch sewer into which flows the major part of the sewage of the city. All the sewage used in the tests was pumped from this sewer.

VOLUME OF SEWAGE FLOW

According to data in Mr. Bradbury's report of December, 1910, the average daily volume of sewage in dry weather is about 11,000,000 gallons. In the above report, it was estimated that of the total daily sewage flow, from 4,000,000 to 6,000,000 gallons consists of water from sources other than that of the municipal water supply, a large portion of which is attributable to leakage of ground water into the sewers.

VOLUME OF INDUSTRIAL WASTES

During the tests, careful studies were made of the quantity and character of the varied manufactural wastes of the city, since both as regards the volume and the chemical composition of these wastes were indications strong that their influence upon the Akron sewage problem would be of special moment. Of the total number of manufacturing plants in Akron, only the wastes from the Alkali Rubber Works, The Diamond Reclaiming Plant, and the Salt Works at present are discharged into the ctiy sewers. The volume of wastes from these three plants is about 600,000 gallons per day, or about 5.5 per cent. of the average daily sewage flow.

SEWAGE USED IN TESTS

All sewage tested was pumped from a manhole near the outlet of the 42-inch sewer. The suction of the pump was so located that the sewage was drawn from a point slightly below the average depth of the liquid flowing in the sewer. The sewage was delivered by the pump through an iron pipe force main to the grit chamber, at the outlet of which were collected all samples of the crude sewage. None of the sewage tested was screened, after it had passed through the strainer at the end of the suction pipe in the sewer. The holes in the strainer were ¼ inch in diameter.

ANALYTICAL WORK

Complete analyses were made of the crude Akron sewage daily during the tests in accordance with the following sampling schedule:

Sampling Schedule: Sampling was begun each morning at 7:00 o'clock and continued up to and including 6:00 o'clock a. m. on the following day. Each hour there were collected 100 c. c. portions of crude sewage and of the effluents of the different devices . All tanks and filters were sampled on the same day. Beginning August 27, and continuing to the end of the tests, the hourly portions were collected over a period of 48 hours and were then mixed to form one composite sample. Each morning before the first hourly portion was added to the sample bottle, chloroform was added in the proportion of 10 c. c. per gallon of sewage.

Measurements of the volume of sewage pumped were made hourly. Four times during the 24 hours, at 6:00 o'clock a. m., 12:00 noon, 6:00 p. m. and 12:00 o'clock midnight, there was observed the temperature of the air and that of the raw sewage and effluents.

For putrescibility, samples were collected at 11:30 o'clock a. m., a time when the strongest sewage of the city was passing through the tanks and through the filters.

Samples of sludge from the different tanks were collected from time to time to show variations in the rate of accumulation and differences in chemical composition. Samples were obtained by forcing a small bucket into the sludge and dragging the bucket along the bottom of the tank. This operation was continued until the sampling had extended over the entire deposit of sludge. Portions collected from different sections of the tank were mixed together to form one composite sample.

METHODS OF ANALYSIS

In general there were employed standard methods of sewage analysis in full conformity with the official recommendations of the Committee on Standard Methods of the American Public Health Association. The carbonaceous material, as measured by the quantity of oxygen consumed from a hot acid permanganate solution was determined by immersing in boiling water for 30 minutes with an excess of permanganate, a flask containing a sample of sewage diluted to 100 c. c. After digestion, the excess of permanganate was titrated with ammonium oxalate. Organic nitrogen was determined by adding 5 c. c. of concentrated sulphuric acid to the sample of sewage or effluent direct without boiling off the free ammonia. After the reduction of the organic matter to ammonium sulphate, the acid was neutralized with either sodium or potassium

hydrate, and allowed to stand 48 hours. A small portion of the supernatant liquid was then pipetted off, diluted with ammonia-free water to 50 c. c. and nesslerized in the usual way.

In determining the free ammonia, two drops of 50 per cent. solution of sodium or potasium hydrate were added to 100 c. c. of the sample. The samples were then allowed to stand 24 hours to permit the precipitate to settle. Two c. c. of the water liquid were then removed by a pippette, and the ammonia was determined in the usual manner by nesslerization.

The organic nitrogen was obtained by deducting the nitrogen as free ammonia from the total nitrogen.

Suspended matter was determined on measured portions of the sample by filtration through a tared Gooch crucible.

Dissolved oxygen was determined by the Winkler Method. Nitrites and Nitrates were determined by the reduction method. The Nitrites were separately determined and deducted.

Putrescibility tests were made in bottles holding 250 c. c. One c. c. of methylene blue was added to the sample and the mixture was incubated at room temperature. In converting parts per million of dissolved oxygen to relative stability numbers, there were made slight corrections for temperatures between 20 deg. and 37 deg. C. Ordinarily, the results were computed with respect to stability at the lower temperature.

AVERAGE RESULTS OF ANALYSES OF CRUDE AKRON SEWAGE

The tests were started on December 27, 1911, and were continued until September 23, 1912. During this period there were made 103 analyses of crude sewage, consisting of 2,616 portions collected hourly and mixed in equal proportions. The average data by months, shown in Table No. 1, are weighted proportionately to the number of samples collected in any month. It is of interest to note the unusually high chlorine, indicative of the salt in the Akron sewage, and also the constant presence of nitrites and dissolved oxygen, constituents which show marked dilution with ground water.

TABLE No. 1

Monthly Average Results of Analyses of Crude Sewage

1912 Date	Temp. Deg. C.	PARTS PER MILLION													
		NITROGEN AS					Oxygen Cons'd				Suspended Matter				
		Total Organic	Diss. Org.	Free Amm.	Nitrites	Nitrates	Total	Dis'd	Susp'd	Chlorine	Total	Volatile	Fixed	Alkalinity	Dissolved Oxygen
February	11	7.3	..	6.5	..	..	76	..	..	1809	200	96	104	...	..
March	8	10.5	..	5.7	.09	..	79	..	..	684	265	106	159	216	..
April	12	11.1	..	5.4	.16	..	82	..	..	712	201	93	108	218	..
May	16	11.5	7.1	7.2	.15	..	92	75	17	598	232	96	136	253	30
June	20	11.7	7.0	8.0	.15	..	100	78	22	711	307	192	115	275	23
July	24	10.1	6.7	7.7	..	..	81	59	22	1067	250	141	109	249	13
August	23	11.1	6.1	6.4	.12	.53	91	71	20	1391	259	138	121	254	19
September	23	10.5	7.7	6.5	.15	.41	91	72	19	1419	215	134	81	230	18
Wgt'd Av.	15	10.6	6.9	6.6	.13	.51	86	..	..	917	238	124	114	238	22

Note—Dissolved oxygen results are in terms of per cent saturation.

DISCUSSION OF LEADING CONSTITUENTS OF THE CRUDE SEWAGE

Certain important features of the local sewage as brought out by the anlyses are next discussed.

Freshness. As shown by the anlyses, the Akron sewage is what may be called a fresh sewage. During the tests there was but little evidence that septic action had taken place in the sewers. The presence of dissolved oxygen and nitrites at all times indicates that the sewage undergoes but little putrefaction during its flow through the sewers.

Suspended Matters. Careful measurements were made of the deposit of sand in the grit chamber. This chamber was a wooden box, 6 inches wide, 5 feet long and 8 inches deep. Under the average rate of pumping, the velocity of sewage in the grit chamber was 60 feet per minute. The average depth of flow was 4 inches. Under the above high velocity there were deposited only the heavier suspended solids carried by the Akron sewage. These matters, chiefly sand, were present at all times in the sewage. The total quantity of material removed from the grit chamber from April 11 to September 6 was 1.26 cubic yards. The total quantity of sewage pumped during this period was 6,770,000 gallons; hence, the deposition of sand was 0.19 cubic yards per million gallons. These data point strongly to the necessity for grit chambers when there shall be planned sewage works for the City of Akron.

The daily analyses of composite samples of crude sewage when averaged and weighted, afford reliable data regarding the total suspended matters in the local sewage after the removal of sand by the grit chamber. During the period covered by the analyses, that is from February 13th to September 10th, the maximum, minimum and average suspended matters in the crude sewage were, 528, 62 and 238 parts per million respectively, or 2.21, 0.26 and 0.99 tons

per million gallons, respectively, all reduced to a dry basis. The maximum quantity was noted in June when, largely due, it would appear to low rainfall, the sewage became more concentrated. The data in Table No. 2 show that all the organic matter constituents were higher in June than at any other time during the tests.

In the next table are shown the average, maximum and minimum quantities of dry suspended matter, by months, as expressed in parts per million, and tons per million gallons.

TABLE No. 2

Dry Suspended Matter in Crude Sewage

Month 1912	Dry Suspended Matter					
	Parts per Million			Tons per Million Gallons		
	Max.	Min.	Av.	Max.	Min.	Av.
February	380	92	200	1.59	0.38	0.84
March	450	80	265	1.88	0.33	1.11
April	352	62	201	1.48	0.26	0.84
May	433	111	232	1.81	0.46	0.97
June	528	199	307	2.20	0.83	1.28
July	460	116	250	1.92	0.48	1.04
August	390	148	259	1.63	0.62	1.08
September	236	191	215	0.99	0.80	0.90

Colloidal Matter. Ordinarily, the sewage contained unusually small quantities of colloidal matter which may be defined as those substances of a gelatinous nature partly in solution and partly in suspension in the sewage. From a practical standpoint, colloidal matter may also be considered as that portion of the suspended solids which will not settle out in a reasonably short period of time. Generally speaking, the quantity of colloidal matter in Akron sewage may be taken roughly as 25 parts per million.

Nitrogenous Organic Matter. The nitrogenous organic matter in the sewage is measured by the nitrogen as organic matter and by that as free ammonia. The average results of the analyses of the local sewage as shown in Table No. 1, indicate that the Akron sewage is of average organic content. During the tests, the organic nitrogen ranged from a maximum of 17.0 to a minimum of 5.4 and averaged 10.6 parts per million. The free ammonia similarly showed maximum, minimum and average values of 9.5, 3.0 and 6.6 parts per million, respectively. Six and nine-tenths parts of organic nitrogen in the crude sewage was in solution.

Carbonaceous Organic Matter. Oxygen consumed, a constituent of the crude sewage shown in the analyses, indicates the approximate proportion of organic matters of a carbonaceous nature. This determination indicates also the presence of iron salts and all other substances of a reducing character. The maximum, minimum and average values of the oxygen consumed were, respectively, 193, 23 and 86 parts per million. Of the average 75 parts per million or 87 per cent. were in solution. These data indicate that a large part of the carbonaceous organic matters are dissolved in the sewage.

Chlorine. Chlorine in a sewage analysis indicates the quantity of common salt or sodium chloride. Under ordinary conditions, this constituent indicates the strength of the sewage as regards the relative quantity of impurities in a given volume of liquid. Under Akron conditions, however, on account of the salt introduced from the salt works, the chlorine results bear no relation to the relative organic matter strength of the crude Akron sewage.

During the tests, the chlorine ranged from a maximum of 2248 to a minimum of 248, and averaged 917 parts per million. The average result corresponds to about 1500 parts per million of salt, or 6.27 tons per million gallons. On the basis of the average analyses during these tests, and considering a daily sewage flow of 11,000,000 gallons, it is apparent that the Akron sewage would contain in 24 hours, about 69 tons of salt.

Mineral Constituents. The suspended matter data indicate that slightly less than half of the suspended solids in the sewage are of a mineral nature. Additional information regarding the mineral matters of the Akron sewage may be drawn from the alaklinity, which measures the quantity of carbonates of lime and magnesium. The alkalinity determination is of value in case there mingles with the sewage manufactural wastes which contains an excess of either alkali or of acid. Due to the effects of soaps and other alkalies introduced into the sewers, the average alkalinity of sewage is usually somewhat in excess of that of the water supply. The maximum, minimum and average alkalinity of the Akron sewage during the tests were 420, 150 and 238 parts per million, respectively.

INDUSTRIAL WASTES

The leading industrial establishments of the city are the rubber mills, the sewer pipe works, the cereal mills, the salt works, the foundries, the breweries and the paper mill. Of these industries, only the rubber mills, the salt works and the paper mill produce wastes that are likely to interfere with ordinary sewage purification processes. There is a small quantity of liquid wastes from the sewer pipe works, from the foundries, and from the breweries, but the wastes are not of a character such as to bear any important relation to the treatment of the sewage of the city. At the present time, the liquid wastes from all of the above mills except the rubber reclaiming plants, the salt works, and the breweries enter the Canal or the Little Cuyahoga River.

In order to determine the nature of the different wastes, samples were collected from the different outlets covering a period of 10 hours. Although all the mills were operating 24 hours per day at the time the samples were collected, as the same processes prevail throughout the 24 hours, it was thought that a 10-hour period of sampling would correspond to average conditions for the full day. All the other mills from which samples were collected were operating 10 hours per day and samples from these plants, therefore, covered the entire working day. Samples were collected every 20 minutes and mixed together at the end of the sampling period to form one composite sample. Table No. 3 shows the analyses of the samples of industrial wastes from the different sources.

TABLE No. 3

Results of Analyses of Wastes from Rubber Mill Salt Works and the Paper Mill

Source of Sample	Date 1912	Suspended Matter			Nitrogen as		Oxy. Cons.	Chlorine	Alkalinity	
		Total	Vol.	Fixed	Org.	Free Am.				
Alkali Rubber Co.....	8-30	440	263	177	8.9	2.3	17	360	720	(1)
Alkali Rubber Co.....	8-30	3938	3156	782	9.0	0.26	474	500	1120	(2)
Alkali Rubber Co.....	9-5	1658	922	736	0.96	0.14	33	725	4100	(3)
Buckeye Rubber Co....	9-5	19	15	4	1.1	0.11	12	5	114	(4)
American Tire Co.....	7-15	28	8	20	2.5	0.08	28	823	150	(5)
Colonial Salt Co.....	9-9	65	19	46	1.3	2.1	64	74000	58	(6)
Diamond Rubber Co...	8-21	18	9	9	0.32	0.06	2	280	130	(7)
Colonial Salt Co.....	9-10	26	8	18	0.62	1.1	46	42000	66	(8)
Diam. Reclaim. Plant..	9-12	716	580	136	....	....	.....	.....	.....	(9)
Diam. Reclaim. Plant..	9-13	448	324	124	....	....	454	800	360	(10)
Firestone Rubber Co..	8-23	17	9	8	0.13	0.10	8	310	120	(11)
Firestone Rubber Co..	8-23	10	.7	3	0.16	0.07	8.5	320	110	(12)
Firestone Rubber Co..	8-24	366	158	208	0.17	0.08	9.4	320	120	(13)
Goodyear Rubber Co..	9-18	694	312	382	12.0	1.2	235	400	160	(14)
Goodyear Rubber Co..	9-17	9164	8464	700	23.00	7.0	10250	2500	-560	(15)
Goodyear Rubber Co..	9-18	42	18	24	2.9	0.16	20	20	150	(16)
Goodrich Rubber Co..	8-16	41	20	21	2.44	0.12	16	275	125	(17)
Goodrich Rubber Co..	8-19	53	24	29	0.30	0.12	2.9	280	130	(18)
Goodrich Rubber Co..	8-20	41	11	30	0.32	0.08	2.2	300	130	(19)
Miller Rubber Co.....	8-27	262	184	78	5.9	0.16	1133	180	270	(20)
Swinehart Rubber Co..	8-12	15	8	7	1.3	0.05	11	897	130	(21)
Swinehart Rubber Co..	8-13	26	9	17	2.8	0.14	8	897	240	(22)
Swinehart Rubber Co..	8-12	156	120	36	15.0	5.5	105	923	170	(23)
Swinehart Rubber Co..	8-13	958	348	610	25.0	7.5	207	923	230	(24)
Philipps Paper Co.....	8-16	328	87	241	4.3	1.0	74	698	280	(25)
Philipps Paper Co.....	8-17	439	136	303	5.7	0.4	173	698	270	(26)
Cuyahoga River	8-6	40	22	18	0.40	0.48	15	8	104	(27)

1. One portion collected at 9 a. m.
2. Composite sample, 8 a. m. to 5 p. m.
3. Composite sample, 8 a. m. to 5 p. m.

4, 5. Wastes discharge into Cuyahoga River.

6. Connected with sewers.
7. Discharge into canal.
8. Discharge into sewers.
9. Discharge into sewers.
10. Discharge into sewers.
11. Sample from vulcanizer.
12. Sample from condensing water.
13. Sample from cooling machines.
14. Sample from scrubbers.
15. Small volume, discharges into river.
16. Cooling water, large volume, enters river.
17. Condensing water from power house.
18. Wash and cooling water from scrubbers.
19. Hot condensing water.

20. From scrubbers.
21. Wash water.
22. Wash water.
23. From scrubbers.
24. From scrubbers.
25, 26. Fine precipitate and small bits of paper in samples.
27. Below Goodyear Rubber Co. outlet.

Inspection of the data shows that the two rubber mills connected with the city sewers produce wastes much stronger than that of any of the others. The waste from the salt works, drainage from which enters the sewers, carries but little suspended matter, but contains in solution a large quantity of salt (sodium chloride). The average quantity of chlorine in the two samples was 58,000 parts per million, or 5.8 per cent. chlorine or 9.5 per cent. sodium chloride. The suspended matter in the wastes from the industrial plants of the city is not excessive except from the two plants which reclaim rubber. Furthermore, the solid matters from these plants are insufficient materially to increase the suspended matter normally present in the crude sewage.

The Little Cuyahoga River and the Ohio Canal receive the wastes from the mills not sewered into the city sewers. To ascertain the effect of the wastes which enter the river upon conditions in the river water, a sample of river water was collected at a point 300 feet below the outlet of the mill farthest down stream. The results of the analysis of this sample, as shown in Table No. 3, indicate that at present, the volume of river water is amply sufficient to dispose of these wastes in a satisfactory manner. There were no sludge deposits near the mills nor in the channel of the river farther down stream.

Observations made along the canal below the rubber mills showed some gas ebullition. This is attributable, no doubt, to a number of features, chief of which are the sluggish current, the presence of rubbish, slight contamination by domestic sewage, and the continuous discharge of hot water by the rubber mills. The relatively high temperature of the canal waters and the presence of organic matter encourages putrefication in the deposits in the bed of the canal. The quantity of suspended matter solids which enter the canal is small and although at some future time these solid matters may give rise to a nuisance, or form objectionable deposits in the canal, yet the evidence obtained during this investigation clearly indicates that, at the present time, the existing disposition of the wastes is the most practicable means available for their disposal. In the future, if conditions, due to these wastes, become objectionable, it will be necessary to dredge the canal from time to time, or else to construct settling basins at the mills to remove the solid matters in large part, thus to prevent their entrance into the canal.

DISCUSSION OF MANUFACTURAL WASTES AS AFFECTING THE COMPOSITION OF THE LOCAL SEWAGE

Results of the average analyses of the crude sewage, as shown in Table 1, and the daily analyses in the appendices, indicate that with exception of the increased chlorine, and but rarely with respect to suspended matter, the normal domestic character of the Akron sewage prevails. In other words, the industrial wastes of an offensive nature, or containing chemicals, suspended matters,

or other constituents, is too slight, appreciably to affect the composition of the crude sewage. The appearance, at times, of marked evidences of industrial wastes at the outlet of the trunk sewer may be explained by the fact, as developed during these tests, that, at times, from certain of the mills, there are discharged, for comparatively short periods, liquids highly charged with suspended matter and chemicals. While these discharges in no way affect average results yet their discharge into the sewer, covering such short space of time, results in such small dilution that the presence of these wastes is readily noted at the point of outfall.

The general conclusions from the critical study of the industrial waste situation is that the industrial wastes discharged into the sewers of the city do not materially affect the average composition of the crude Akron sewage. The relative volume of the wastes is so slight that their identity will, no doubt, be lost at the purification works.

COMPARISON OF AKRON SEWAGE WITH THAT OF OTHER CITIES

The fact that the industrial wastes which enter the Akron sewers do not appreciably affect the average composition of the local sewage is clearly indicated by the data in the next table in which are given the average results of analyses of the crude sewage from a number of representative cities in the United States. It will be noted that the local sewage is slightly weaker than the sewage of Columbus, O., and that it contains less organic matter than the sewage of Waterbury, Ct., or of Gloversville, N. Y.

TABLE No. 4

Average Analysis of Akron Sewage Compared with the Sewage of Other Cities

Place	Parts Per Million				
	Oxygen Consumed	Nitrogen as		Chlorine	Suspended Matter
		Organic	Free Amm.		
Akron	86	11.0	6.6	917	238
Columbus	51	9.0	11.0	65	215
Philadelphia	76	6.3	4.0	39	189
Gloversville	95	23.0	12.0	158	406
Waterbury	46	15.0	7.8	48	165
Chicago	38	7.6	8.8	40	141

DESCRIPTION OF TESTING STATION

Details of the Test Devices are here described. Reference should also be made to the annexed plans which show the general arrangement of the station and the detailed design of the tanks and filters.

Location of Station

The testing station was located on about one-quarter acre of leased land along the Little Cuyahoga River, at Lock 16 of the Ohio Canal. The station

GENERAL VIEW OF TESTING STATION

was about 240 feet east of the 42-inch trunk sewer and opposite a point about 500 feet above the outlet of the sewer into the river.

General Arrangement of the Test Devices

The layout of the station is shown on Plate I. In brief, the station included:

1. A pumping plant consisting of a pump, gas engine and force main.
2. A narrow wooden tank for the study of the removal of sand from the local sewage.
3. Three tanks for the study of preparatory treatment, that is for the removal of suspended matter.
4. Three tanks for studying sprinkling filters.
5. Three settling basins auxiliary to the sprinkling filters.
6. Two tanks for investigating contact filter treatment.
7. One circular tank for the study of sludge digestion.
8. Orifice boxes for measuring the sewage flow.
9. Laboratory building with complete equipment for testing sewage and sewage effluents.

Pumping Plant

The pumping equipment comprised a 1½-inch centrifugal pump directly connected to a 2½ H. P. gas engine. The pump and engine were housed by a frame structure built over and above a 42-inch sewer. The suction pipe, enlarged to 4 inches, extended to the bottom of the sewer to an elbow, thence by a close nipple to a second elbow placed in a direction at right angles to the flow in the sewer. To the second elbow there was attached a loose nipple which extended down the sewer about 4 feet. This nipple was supported by a chain and the end of the pipe ordinarily was maintained at a point slightly below mid depth of the sewage stream. The end of the suction pipe was enclosed in an iron strainer with ¼-inch perforations.

Grit Chamber

All the sewage tested was pumped into the grit chamber. This was a wooden flume 6 inches wide, 8 inches deep, and 5 feet 11 inches long, baffled as shown on the plans, and provided with an outlet weir. The tank was not covered.

Imhoff Tank

The Imhoff tank consisted of a circular wooden tank, 8 feet in diameter and 16 feet deep. Distant 11 feet 4 inches from the top of the tank, by means of concrete, there was formed an inverted cone 4 feet high. Sewage was supplied to the tank through a 2-inch iron pipe, and was applied through a circular gutter which extended the full width of the sedimentation chamber, formed by wooden partitions 4 feet 6 inches high. At the bottom of the vertical side, the partitions sloped toward each other at an angle of 45 degrees to a slot opening of 2 inches. The total depth of the tank below the slots was 7 feet. The tank was baffled by a vertical partition in the center of the sedimentation chamber. This partition extended 5 feet below the flow line. Sewage flowed out of the tank over a curved gutter which extended across the full cross section of the sedimentation compartment. Sludge was removed from the tank through a 4-inch iron pipe which extended to the bottom of the cone-shaped section of the tank. The upper end of the sludge pipe was so located

that the head on the sludge was 7 feet. A valve was placed on the sludge line a short distance outside the tank.

The total volume of sewage and sludge in the Imhoff tank was 4,693 gallons. The capacity of the sedimentation compartment was 2,030 gallons.

Dortmund Tank

The Dortmund tank was a cypress tank 7 feet in diameter and 10 feet 6 inches deep. At a point 6 feet 6 inches below the top, there was formed, of wood and plastered with concrete, a conical compartment 4 feet deep, which extended to within 6 inches of the bottom of the sludge compartment and served for the withdrawal of sludge. The sludge pipe passed out of the tank at such a point that the hydrostatic pressure on the sludge was 4 feet 5 inches. Sewage was applied to the tank through a 2-inch iron pipe which extended downward in the center for a distance of 5 feet below the flow line. The effluent flowed out of the tank through holes in the bottom of a galvanized iron trough which extended entirely around the periphery. Three pipes lead from the outlet channel, one each to the sprinkling and contact filters, and one to the drain. The flow line capacity of the Dortmund tank was 2,017 gallons. The capacity above the cone was 1,641 gallons.

Septic Tank

A rectangular wooden tank, 4 feet wide, 12 feet 6 inches long, and 9 feet 2 inches deep was operated as a septic tank. The tank was 4 inches deeper at the outlet than at the inlet, and, for the removal of sludge, there was an 8-inch shear gate which was connected to the drain. Sewage was applied through a 2-inch iron pipe which extended vertically downward to a point 3 feet below the flow line. The treated sewage flowed out of the tank through a 2-inch iron pipe which extended from a point 3 feet below the flow line to an elbow at the flow line, and then passed through the end of the tank. Outside the tank, the pipe extended to a point 4 feet 9 inches below the flow line. The septic tank was not covered. There were two baffles, one 4 feet from the inlet and the other 4 feet from the outlet end of the tank. The first extended 4 feet below the flow line, and the second 4 feet upward from the bottom. No scum baffles were provided.

The capacity of the septic tank to the flow line was 3,032 gallons.

Sprinkling Filters

The three sprinkling filters were constructed of cypress lumber nailed to studding, and were erected upon a base of concrete 4 inches thick. Four by fours, spaced 2 inches on centers, were laid upon the concrete. The space between the 4 by 4's was filled with concrete at the back of the filters, and sloped to a zero fill at the outlet ends. At right angles to the 4 by 4's, there were laid 2 by 4's, spaced 6 inches center to center. These were held in place by toe nailing and by blocks set in between the timbers.

Upon the above base, were carefully placed field stones 4 inches in diameter. The filtering material was then placed to the desired depth. Sewage was applied to the filters through a 2-inch iron pipe in the center of the filter. Distribution was effected by a Taylor nozzle of the circular type. The head on the nozzles was, ordinarily, 5 feet. The three sprinkling filters were 13 feet 7 inches in diameter. Two of the filters were provided with wooden partitions at the

corners placed at an angle of 45 degrees with the sides of the tank. The area of the two tanks so constructed was 145 square feet, or 0.0033 acre, assuming the filter as circular. The actual area of the third tank was 184 square feet, but as the filter was dosed with a circular nozzle, the effective area is that of a 13-foot 7-inch circle, or 145 square feet. The sprinkling filters were, at all times, exposed to the weather.

Filter No. 1 contained 5 feet of sewer pipe, broken to a size which ranged from 1¾ inches to 2½ inches.

Filter No. 2 contained 5 feet of limestone which ranged in size from 1¾ inches to 2½ inches.

Originally, Filter No. 3 contained material of the same kind and depth as that in Filter No. 2, but on August 9, the depth was increased to 6 feet by the addition of more stone of the same size.

Settling Basins for Sprinkling Filters

Tributary to each sprinkling filter there was a settling basin, 5 feet square in plan, and 4 feet 3 inches deep, constructed of 2-inch lumber. The effluent from each of the sprinkling filters was collected in a concrete gutter, and flowed over a weir into the respective settling basins. In each basin there was a vertical baffle which extended to the bottom of the tank, and to within 18 inches of the side. The settled effluent passed out of the basin over a weir, thence into the collecting channel, whence, by a drain, it was carried to the river. The settling basins were uncovered. The working capacity of the basins was 700 gallons each.

Contact Filters

The two contact filters operated at the station consisted of wooden tanks, 5 feet in diameter, and 5 feet 8 inches deep. Drainage to an outlet was effected by placing a sloping layer of concrete in the bottoms of the tanks.

These two tanks were filled with filtering material to an average depth of 5 feet. No. 1 contained chuck or broken sewer pipe, ranging in size from 1¾ to 2½ inches. No. 2 contained limestone ranging in size from ½ to ¾ inches.

Sewage was applied to the filters through a 2-inch iron pipe controlled by a valve. The effluent was drawn off through a collecting channel at the bottom Regulation was afforded by a gate valve attached to a 2-inch iron pipe which was screwed into the side of the tank.

The area of each contact filter was 1,963 square feet, or 0.00045 acre.

Sludge Tank

For the study of sludge digestion, there was provided a wooden tank 5 feet in diameter and 6 feet deep. At the bottom of the tank there was a 2-inch iron pipe controlled by a valve. Wooden chutes were provided for conveying the sludge from the Imhoff and Dortmund tanks to the sludge tank.

Orifice Boxes

To control the operation of the station, orifice boxes were provided, as shown on the plans. There were three orifice boxes one each for the control of the three preparatory tanks. From the grit chamber, the sewage flowed into all of the three boxes continuously; the excess pumpage flowed over a weir into the station drain. The elevation of the water on the overflow weir determined the head upon the tank orifices.

The orifice boxes were 9 inches wide, 3 feet long, and 15 inches deep.

The boxes were connected to the grit chamber by a 4-inch pipe. Water tight connections were obtained with flanges. The end of each 4-inch pipe in each box was provided with a cap which was tapped in the center, leaving a shoulder which held in place a brass orifice plate. The opening in the orifice was fixed, and was computed on the basis of the known desired period of flow through the preparatory device, and for an effective head of 1.0 foot.

Laboratory Building

The laboratory control of the operations at the testing station was carried out in a building located as shown on the general plan. The building was a frame structure 18 by 22 feet, and divided into five rooms of the following dimensions:—Chemical Laboratory, 12 by 18 feet; preparation room, 10 feet by 7 feet 3 inches; bacterial laboratory, 7 feet by 7 feet 9 inches; office, 7 by 9 feet.

The laboratory was equipped for making complete chemical analyses. The preparation room was arranged for receiving and storing samples during the period of collection and for washing the apparatus. As no bacterial analyses were made at the station, the bacterial room was used for special studies. The office included a desk and drawing table, and also served for the storage of chemicals and apparatus.

Preparatory Treatment

Preparatory treatment is a term applied to those processes by which there are removed from sewage, a part of the matters carried in suspension. Such a result is effected by causing the sewage to enter tanks of different shapes and dimensions in which the velocity is checked and an opportunity thus afforded for the suspended matter to settle out. In recent years there have been marked developments with respect to preparatory treatment by sedimentation, particularly in England and Germany. At the Akron Testing Station, there were studied two of the foreign tanks,—one an Imhoff tank and the other a Dortmund tank.

Operation and Control

Sewage was applied to the preparatory devices from the orifice tanks into which flowed the sewage from the grit chamber. The rate of flow through each of the preparatory treatment tanks was controlled by maintaining a constant head upon a brass orifice, the area of which was originally computed on the basis of the effective water capacity of the tank, and the desired period of flow.

Measurements of Flow

At frequent intervals during the tests, there were made measurements of the rate of flow through the three tanks by lowering the water level and noting the time required to refill to the flow line, when fed from the respective orifice boxes.

Collection of Samples

Composite samples for analyses consisted of hourly portions collected on days when the crude sewage was sampled and mixed together in equal portions at the end of the 24- or 48-hour period.

Measurements of Sludge

The progressive accumulation of sludge was determined by frequent meas-

urements of the deposit in the three tanks. The volume of sludge deposited at any time was determined by means of a graduated rod to the end of which was attached a glass bottle provided with a rubber stopper. To the top of the stopper was fastened copper wire of sufficient length to extend above the surface of the liquid in the tank. When making the measurement, the bottle was lowered to a given point, and the depth of water noted on the rod. The stopper was then withdrawn, the bottle raised to the surface and examined for sludge. This process was repeated for increments of one inch, until the surface of the sludge was reached. Sufficient measurements were made in the above manner to obtain average data over the entire bottom of the tank.

Results Accomplished by Imhoff Tank

Supplementing the description of the Imhoff tank previously made, it is of interest to record that the Imhoff tank, as a device for the preparatory treatment of sewage, was originated by Dr. Karl Imhoff of Essen, Germany, in connection with sewage disposal studies for the Sanitary District of the Emscher River. The Imhoff tank differs essentially from all other settling tanks, and particularly from the septic tanks, by virtue of the fact that the compartment in which the sludge accumulates is very deep,(25 to 40 feet in some places) and is entirely separate from that which contains the flowing sewage. Furthermore, by an arrangement of projecting partitions, it is not possible for the products of decomposition of the sludge to mingle with the flowing sewage.

The horizontal flow Imhoff tank, of which the test device is a type, consists of a circular sludge well with a conical bottom, and contains in a direction parallel to the sewage flow a sedimentation compartment formed by vertical and sloping partitions. The vertical partitions ordinarily afford an effective depth of 4 or 5 feet. At the bottom of this section of the upper compartment, there are two partitions which slope sharply to the vertical, and are inclined towards each other and towards the center of the tank. One partition extends sufficiently below the other to form an opening or slot through which the settling solids gravitate into the sludge compartment. The space between the vertical partitions and the circular walls of the sludge well is known as the gas compartment, and serves as an outlet for the gases which form in the sludge, and, from time to time escape into the atmosphere. Another important feature of the Imhoff tank is the ability to withdraw sludge without interrupting the operation of the device as a whole. This is effected by a pipe which extends upward from the bottom of the conical portion of the sludge well, and passes out at a point such that the hydrostatic pressure on the sludge is from 5 to 7 feet. Ordinarily, the sludge pipe is closed by a valve. The Imhoff tank is one of the latest developments in preparatory sewage treatment, and has been adopted by a number of cities in the United States. A test tank was included in the Testing Station lay out, as it was expected that favorable results would be obtained by the use of this tank as a preparatory treatment of the local sewage.

Period of Flow

The total water capacity of the Imhoff tank, including the sedimentation and sludge compartments, was 4,693 gallons. The capacity of that portion of the tank above the slots, that is the sedimentation compartment, was 2,038 gallons. Careful measurements during the tests developed that the average period of flow in the Imhoff tank was 2.3 hours.

Results of Analyses

In Table No. 5 are recorded monthly average results of the analyses of the effluent from the Imhoff tank. The removal of organic nitrogen was 17 per cent, and that of oxygen consumed was 12 per cent. The nitrogen, as free ammonia, increased on an average from 6.6 parts per million in the applied sewage, to 7.0 parts per million in the effluent of the tank. During the warmer months, especially in June and July, as discussed beyond, there was a decided increase of free ammonia, incidental to the abnormal development of fermentation in sludge deposited upon the side of the partitions.

TABLE NO. 5

Monthly Average Results of Analyses of Effluent of Imhoff Tank

1912 Month	Temp. Deg. C.	Nitrogen as				Oxygen Cons.	Chlorine	Susp. Matter			Alkalinity
		Org.	Free Amm.	Nitrites	Nitrates			Tot.	Vol.	Fixed	
February	10	7.0	6.5			74	1804	87	45	42	
March	9	9.2	6.1	.09		76	705	101	41	60	212
April	12	9.8	5.5	.17		72	716	104	51	53	207
May	16	9.1	8.1	.14		82	593	120	68	52	256
June	20	9.3	8.8	.14	.62	90		180	104	76	
July	24	7.8	7.8	.18	.32	79		183	101	82	
August	22	7.4	7.5	.13	.23	80		127	70	57	
September	23	8.2	8.1	.18	.26	85		114	73	41	
Average	15.4	8.8	7.0	.14	.38	76	825	123	65	58	222

Removal of Suspended Matter

The important function of the Imhoff tank as a preparatory process is, of course, the removal of suspended matter. During the 8½ months in which the Imhoff tank was operated, there passed through the tank 4,700,000 gallons of sewage. This sewage contained, on an average, 238 parts per million of suspended matter. The maximum, minimum, and average removals of suspended matter accomplished by the Imhoff tank were, 61.9, 26.8 and 48.4 per cent. In Table No. 16 are shown the average removals of suspended matter by the preparatory devices, by months. The minimum results obtained from the Imhoff tank were in July and were attributable to the clogging of the slots by suspended matter. This conditon was not noted for several days and hence the average for July was abnormally low. In view of this fact, it seems correct to conclude that, for average conditons, there was removed by the Imhoff tank, 50 per cent. of the suspended matters of the applied sewage.

Fermentation in Sludge

After about six months operation, pronounced fermentation developed in the

sludge of the Imhoff tank. This was evident by the copious ebullition of gas, by the formation of a slight scum, and by the black color of the sewage in the gas compartments. By virtue of the overlapping of the slots peculiar to the Imhoff tank design, sedimentation during this period was in no way influenced, and, as above stated, the low suspended matter removal in July was, no doubt, attributable to the fermentation of the sludge accumlated on the sloping partitions.

Odors

Under normal operating conditons, there developed no offensive odors appreciable a short distance from the Imhoff tank.

Dissolved Oxygen in Effluents

On account of the large infiltration of ground water in the Akron sewers, the sewage usually contained dissolved oxygen, as previously stated. Under conditons which prevailed in the test tank for a period of flow of only 2.3 hours, and, in view of the fact that the design of the tank prevents a contamination of the flowing sewage by fermentation that may insue in the sludge, the effluent from the tank invariably contained nitrites, and, quite frequently, dissolved oxygen also.

Imhoff Sludge

The storage of sludge under comparatively high hydrostatic pressure, a peculiar feature of the Imhoff tank in practice, causes the thoroughly digested sludge to be granular, and filled with minute bubbles of gas. Foreign experiences have shown that when such sludge is withdrawn from the tank, the gas escapes, leaving a porous mass from which the water readily drains. Imhoff tank sludge, therefore, can readily be disposed of by discharge onto properly drained beds of porous sand or gravel. At the end of a few days, there remains a granular mass, largely resembling humus, and without appreciable odor. Such sludge is attained only after a considerable period of operation.

While the locally tested Imhoff tank was not operated long enough to obtain normal data regarding sludge, yet, interesting information was secured when the plant was dismantled at the end of the tests. The major part of the sludge was very homogeneous, entirely black in color, and contained numerous small gas bubbles. The sludge had a slight odor of tar. The sludge removed from the tank at the end of the test flowed readily through the 4-inch sludge pipe. No difficulty was experienced in withdrawing the sludge in this manner, and no water was required to dilute the sludge.

The volume of the sludge found in the Imhoff tank at the end of the tests was 6.93 cubic yards. On analysis, the sludge contained only 74.0 per cent. water, and had a specific gravity of 1.12. The volume of the sewage which entered the Imhoff tank was 4,700,000 gallons. As calculated from the analytical data, the total quantity of dry solid matter retained in the tank was 2.26 tons. Computed to dry solids, the quantity of sludge actually found in the tank at the end of the tests was 1.70 tons. These interesting data are shown in the following table.

TABLE No. 6

Suspended Matter Removed by Imhoff Tank for Total Period Covered by Tests, Computed from Analytical Data and Compared with Quantity of Dry Solid Matter Found in Tanks at End of Operating Period

Average suspended matter in crude sewage (parts per million)	238
Average suspended matter in Imhoff tank effl. (parts per million)	123
Quantity removed (parts per million)	115
Volume of influent (millions of gallons)	4.7
Total dry solids (tons)	2.26
Sludge in tanks, end of tests (tons)	6.55
Per cent. water in sludge	74.0
Dry solids (tons)	1.70

Composition of Sludge

The sludge from the Imhoff tank was examined in July by drawing off a small portion for analysis. Additional data regarding the composition of the sludge were obtained at the close of the tests. The results of these two analyses of Imhoff sludge are shown in the next table, together with analyses of a typical sludge from a septic tank. The important feature of note is that the Imhoff sludge is more compacted, as indicated by the smaller percentage of water, and is lower in nitrogen and higher in fats than sludge from the septic tank.

TABLE No. 7

Analyses of Sludge from Imhoff Tank Compared with That of Typical Septic Sludge

	Imhoff		Septic Sludge
	7-21	End of Tests	
Weight of wet sludge, per cubic yard (tons)	0.928	0.945	0.903
Specific gravity	1.10	1.12	1.07
Per cent. Water	76.5	74.0	84.0
" Solids (dry)	23.5	26.0	16.0
" Volatile matter (on dry basis)	44.8	52.0	43.8
" Nitrogen (on dry basis)	0.80	0.80	0.96
" Fats (on dry basis)	4.98	7.32	6.5

Results Accomplished by Dortmund Tank

The Dortmund tank is a German development in modification of a two-story settling tank, originated by Kniebühler, of Dortmund, Germany. The tank is most favorably viewed as regards its ability to remove suspended matter from sewage. For continued successful operation, it is necessary that sludge be withdrawn as soon as there develops evidences of septic action in

the accumulated sludge. The tank is usually circular in form, and is provided with a conical bottom. Sewage is applied at a point 5 or 6 feet below the surface of the liquid, and flows upward into a circular gutter which usually extends completely around the periphery of the tank. The efficiency of the tank in the removal of suspended matter is largely due to the fact that the flow of sewage is upward, and that the finer suspended matters tend to coalesce, and, hence, owing to their increased weight, more readily fall to the bottom of the tank. It is, of course, necessary that the upward velocity of the sewage be less than the average subsiding velocity of the particles of suspended matter.

By means of a sludge pipe, it is possible to remove sludge from the Dortmund tank without interrupting its operation. In the test device, sewage was applied at the center of the tank, at a point about 5 feet below the level of the water, and flowed upwards and out through holes in a circular channel, as previously described.

Period of Flow

The total capacity of the Dortmund tank was 2,017 gallons. After the tank had been operated for several months, it was found that the normal elevation of the sludge deposited was at a point 6 feet below the surface of the water, that is, 12 inches below the inlet pipe. Considering this 6-foot zone as the sedimentation compartment, the capacity of this part of the tank was 1,641 gallons. The average period of flow in the Dortmund tank was 2.87 hours, a figure based upon a number of measurements as to the rate of filling under the average rate of pumping.

Results of Analyses

The average monthly results of the analyses of the effluent of the Dortmund tank are shown in Table No. 8. By comparison with the crude sewage analyses, it will be noted that there were removed from the tank 21.8 per cent. of the organic nitrogen, and 9.3 per cent. of the carbonaceous matter as indicated by the oxygen consumed. Based on averages, there was a slight increase in free ammonia. This increase was quite pronounced with the advent of warmer weather, and especially during the latter part of the tests, when there developed marked fermentation in the sludge. Detailed results of the analyses of the effluent of the Dortmund tank are shown in the Appendices.

TABLE No. 8

Monthly Average Results of Analysis of Effluent of Dortmund Tank

1912 Month	Temp. Deg. C.	Nitrogen as				Oxygen Cons.	Chlorine	Susp. Matter			Alkalinity	*Diss. Oxygen
		Org.	Free Amm.	Nitrites	Nitrates			Tot.	Vol.	Fixed		
Feb.	9	7.1	6.5	.....	.....	72	1792	85	47	38	.....	...
Mar.	8	8.7	6.6	.09	.....	76	697	98	39	59	212	...
April ...	12	9.5	5.7	.17	.....	71	734	86	38	48	204	...
May	16	8.2	8.2	.12	.....	79	588	95	57	38	254	17
June	20	7.1	8.9	.13	.49	87	.....	121	75	46	.....	2
July	24	8.9	7.9	.20	.32	81	.....	195	102	93	.....	...
Aug.	22	9.0	7.8	.17	.20	87	.....	239	102	137	.....	...
Sept.	23	10.2	8.9	.25	.27	91	.....	284	148	136	.....	...
Wgtd.Av.	15.2	8.6	7.2	.15	.33	78	777	127	65	62	220	8

*Per Cent. Saturation.

Removal of Suspended Matter

The Dortmund tank proved most efficient in the removal of suspended matter during the first 5 months of operation as shown in Table No. 16. So long as sludge decomposition was not pronounced, there was removed by the tank in the vicinity of 58 per cent. of the suspended matter in the applied sewage. From July to the end of the tests, the efficiency of the tank in the removal of suspended matter was gradually reduced, until, during September, there was more suspended matter in the effluent than in the applied sewage. The average removal of suspended matter for the entire period covered by the tests was 46.6 per cent.

Fermentation in Sludge

In connection with the removal of suspended matter, it is interesting to note that the fermentation which developed in the sludge was most pronounced and very much greater than that observed in the Imhoff tank or in the septic tank. It seems probable that this fact may be attributed to the peculiar design of the tank whereby unstable organic matters in a crude state are continuously in contact with the sludge. This feature has an important bearing upon the operation of a Dortmund tank, and suggests that while such tanks serve with great efficiency in the removal of suspended matter, yet in conjunction with their use, there should be provided facilities for the frequent withdrawal of sludge, and ample sludge beds or other means for the disposal of sludge from the tank.

Odors

During the tests, practically no objectionable odors were noted in the vicinity of the Dortmund tank.

Dissolved Oxygen in Effluent

Dissolved oxygen was generally present in the sewage applied to the Dortmund tank, but, as indicated by the analyses, in the passage of the sewage through the tank, the dissolved oxygen was materially reduced. This feature is quite probably attributable, in large part, to the marked fermentation in the sludge.

Dortmund Sludge

When the sludge was removed from the Dortmund tank at the end of the tests, there was found an entirely black homogeneous deposit which had a peculiar odor of tar. The sludge contained fewer gas bubbles than that drawn from the Imhoff tank. Considerable difficulty was experienced in causing the sludge to flow out through the sludge pipe, and it was necessary to loosen up the deposit so that it would flow readily.

The volume of sludge in the Dortmund tank at the end of the tests was 5.82 cubic yards. The sludge had a specific gravity of 1.14 and its total weight was 5.6 tons. The sludge contained 74.0 per cent. water. As there had been previously removed from the tank 1.56 tons of sludge, the total quantity deposited in the tank for the period of the tests was 7.16 tons. The quantity of sewage treated was 2,669,000 gallons. Based upon the analysis of the sludge, the total quantity of dry solids accounted for by deposition in the tank, was 1.86 tons. By calculation from the analytical data, the quantity of dry solid matter removed by the tank was 1.24 tons.

TABLE No. 9

Suspended Matter Removed by Dortmund Tank for Total Period of Tests Computed from Anaytical Data, Compared with Quantity of Dry Solid Matter Found in Tank at End of Tests

Average suspended matter in crude sewage (parts per million)	238
Average suspended matter in Dortmund tank (parts per million)	127
Quantity removed (parts per million)	111
Volume of influent (millions of gallons)	2.7
Total dry solids (tons)	1.24
Sludge in tank, end of tests (tons wet)	5.6
Specific gravity of sludge	1.14
Per cent. water in sludge	74.0
Quantity previously removed (tons wet)	1.56
Specific gravity of sludge	1.07
Per cent. water in sludge	83.8
Dry solids (total, tons)	1.86

Composition of Sludge

After about 6 months' operation, a small quantity of sludge was drawn off from the Dortmund tank. An analysis was made of this sludge, and also of the average sludge found in the tank at the end of the tests. These analyses, together with an analysis of sludge drawn from the tank in the latter part of August, are recorded in Table No. 10.

TABLE No. 10

Analyses of Sludge from Dortmund Tank

Date	7–21	8–29	9–13	9–23
Weight of wet sludge per cubic yard (tons)	0.928	0.937	0.903	0.962
Specific Gravity	1.10	1.11	1.07	1.14
Per cent. water	76.50	75.50	83.80	74.00
Per cent. dry solids	23.50	24.50	16.20	.....
" Volatile matter (dry basis)	44.80	40.00	43.80	.....
" Nitrogen (dry basis)	0.80	0.72	0.96	.....
" Fats (dry basis)	4.98	5.78	6.54	.....

Results Accomplished by Septic Tank

The septic tank was developed in Exeter, England, in 1895. The process consists of passing sewage through a level basin with submerged inlet and outlet in such manner that an opportunity will be afforded for the deposition of the solid matter. Under the action of bacteria, there ensues marked putrefactive decomposition which results in the production of gas, a reduction, by compacting, in the volume of sludge as originally deposited, loss of water, and some gasification and liquefaction. In operation, a septic tank differs from a settling tank chiefly due to the fact that, in the case of the former, sludge is removed from the tank as soon as fermentation develops, while, in the latter, sludge is removed only at long intervals.

Period of Flow

The capacity of the tank studied at the testing station was 3,032 gallons. Under conditions which prevailed during the tests, the rate of application of sewage afforded a period of flow of 7.4 hours. No allowance was made for the volume occupied by the sludge in computing the period of flow. The total volume of sewage which passed through the septic tank was 2,170,000 gallons.

Average Results of Analyses

In Table No. 11 are shown average results of analyses of the effluent from the septic tank. Results of the individual analyses are contained in the appendices. It will be noted that the organic nitrogen was reduced 23.6 per cent., and the carbonaceous organic matter as indicated by the oxygen consumed, 17.4 per cent. There was noted the usual increase of free ammonia, which was 10.6 per cent. It is of interest to note that, at times, nitrites and also nitrates were found in the effluent. In May, the dissolved oxygen in the effluent of the septic tank was 20 per cent. of that required for saturation. During the first three months of the tests, and from the latter part of July until the station was discontinued, dissolved oxygen was absent in the effluent of the septic tank.

TABLE No. 11

Monthly Average Results of Analyses of Effluent of Septic Tank

1912 Month	Temp. Deg.	Nitrogen as				Oxygen Cons.	Chlorine	Susp. Matter			Alkalinity	Diss. Oxygen *
		Org.	Free Amm.	Nitrites	Nitrates			Tot.	Vol.	Fixed		
Feb.	9	6.8	7.0	.....	.....	68	.....	68	37	21	.....	..
Mar.	8	8.5	6.3	.09	.....	74	693	74	33	41	210	...
April	12	9.0	5.7	.16	.....	67	738	65	31	34	206	...
May	15	8.1	7.9	.15	.....	72	573	75	43	32	251	20
June	20	6.4	9.2	.17	.25	75	.....	86	51	35	.....	0.5
July	24	7.1	8.1	.16	.16	63	.....	90	51	39	.....	
Aug.	22	8.6	8.8	.12	.11	74	.....	145	69	76	.....	...
Sept.	23	8.8	10.0	.08	.04	87	.....	266	124	142	.....	...
Wgtd.Av.	15	8.1	7.3	.14	.16	71	681	86	44	42	219	13

*Per Cent. Saturation.

Removal of Suspended Matter

The average removal of suspended matter of the septic tank was 63.9 per cent. The maximum was 72 per cent. This was obtained in March due to considerable quantities of sand and clay carried by the sewage, and in June due to concentration.

The minimum occurred in September, when the efficiency of the tank, considered as a settling basin, was markedly decreased, owing to the active state of fermentation in the sludge. Data regarding the removal of suspended matter by the septic tank are shown in Table No. 16.

Establishment of Septic Action

The septic tank was started in operation on January 1, during cold winter weather. There were practically no evidences of fermentation in the sludge until May, that is after four months' operation. Not until the advent of warm weather in July, when the temperature of the sewage rose to 24 deg. C., was septic action especially pronounced.

Formation of Scum

No appreciable quantities of scum were formed upon the surface of the sewage in the septic tank during the eight and one-half months the tank was operated. Occasionally there would be noted a few patches of light floating matter, but these soon disappeared and did not develop into a permanent crust.

Odors

No objectionable odors were noted from the septic tank.

Dissolved Oxygen in Effluent

Up to the time septic action became established in the tank, the effluent generally contained small quantities of dissolved oxygen, at times as great as 20 per cent. saturation. During the latter part of the tests, when the oxygen in the applied sewage was, on the average, 18 per cent. of the amount required for saturation, none was found in the effluent of the septic tank.

Septic Sludge

The accumulation of sludge in the septic tank was carefully noted as the tests progressed, and carefully measured at four different times. The data observed, shown in Table No. 13, indicate the effect of the heavier matters carried by the sewage during the spring months. The deposition of solid matter was much greater for this period than in June, when the rainfall was slight, and but little mineral matter was carried by the sewage. From July 9 to August 15, the greatest deposition was noted, namely, 3.48 tons of 80 per cent. sludge per million gallons. From August 15 to the end of the tests large quantities of sludge were carried out of the tank, as shown by the small deposition for this period, and also by the analytical data, as previously discussed.

TABLE No. 13

Sludge Deposition in Septic Tank by Periods on Basis of 80 Per Cent. Water

Period, 1912	Operating Days	Volume of Flow, Mill'n Gals.	Sludge Deposited	Tons Per Mill'n Gals.
Jan. 1 to June 4.....	135.5	1.320	4.19	3.17
June 5 to July 9.....	36	0.253	0.49	1.94
July 10 to Aug. 15.....	31	0.336	1.17	3.48
Aug. 16 to Sept. 10.....	24	0.237	0.19	0.80

Calculated from the analyses, the total quantity of dry solid matter removed from the sewage by the septic tank was 1.47 tons. The quantity of dry solid matter found in the tank at the end of the tests was 0.94 ton. During the period of violent fermentation, when the removal of suspended matter was negative, no doubt there escaped with the effluent of the tank suspended matters which were not included in the samples collected for analysis. The data regarding the calculated and observed deposition in the septic tank are shown in Table No. 14.

TABLE No. 14

Suspended Matter Removed by the Septic Tank for Total Period of Tests, Calculated from Analytical Data, Compared with Dry Solid Matter Found in the Tank at the End of the Tests

Average suspended matter in crude sewage (parts per million)	238
Average suspended matter in effluent of septic tank	86
Quantity removed	162
Total volume of influent (million gallons)	2.177
Tons dry solids	1.47
Sludge in tank at end of tests (cubic yards)	4.56
Specific gravity of sludge	1.11
Per cent. water in sludge	78
Dry solids (tons)	0.94

Composition of Septic Sludge

The analysis of the average sludge in the septic tank at the close of the tests is shown in the next table. It is noteworthy that the percentage of water is unusually low for septic sludge.

TABLE No. 15

Analyses of Septic Tank Sludge

Weight of dry sludge per cu. yd. (tons)	0.937
Specific gravity	1.11
Per cent. water	78.0
Per cent. dry solids	12.0
Per cent. volatile matter (dry basis)	43.8
Per cent. nitrogen (dry basis)	0.96
Per cent. fats (dry basis)	6.54

COMPARISON OF PREPARATORY TREATMENTS

As bearing upon the adaptability of the three types of preparatory treatment tanks studied, there will now be reviewed the leading results accomplished.

Period of Flow

The period of flow in the Imhoff, Dortmund and septic tanks was respectively 2.3, 2.87 and 7.4 hours.

Removal of Suspended Matter and Comparative Efficiency

A study of the monthly average removals of suspended matter by these three tanks affords interesting information regarding their relative merits as preparatory devices for the local sewage. The septic tank removed much more

suspended matter than either the Imhoff tank or the Dortmund tank. Up to the time when septic action became pronounced in the sludge in the Dortmund tank, the removal of suspended matter was excellent. Considering the period of flow in the Dortmund tank, as compared to that in the septic tank, and taking into consideration the results accomplished by these two devices, it is apparent that the critical period of flow lies between 3 and 7 hours.

With an allowance for irregularities in operation during July, the Imhoff tank removed in the vicinity of 50 per cent. of the solid matter in the applied sewage. The comparative efficiency of the three tanks studied is clearly shown in the following table.

TABLE No. 16

Monthly Average Removal of Suspended Matter by Preparatory Devices

1912 Month	Suspended Matter Parts Per Million				Per Cent. Removed		
	Crude Sewage	Imhoff Tank	Dortmund Tank	Septic Tank	Imhoff Tank	Dortmund Tank	Septic Tank
February	200	87	85	68	56.5	57.5	66.0
March	265	101	98	74	61.9	63.0	72.0
April	201	104	86	65	48.3	57.3	67.7
May	232	120	95	75	48.3	59.1	67.7
June	307	180	121	86	41.4	60.6	72.0
July	250	183	195	90	26.8	22.0	64.0
August	259	127	239	145	51.0	7.7	44.0
September	215	114	284	266	47.0	-32.0	-23.7
Weighted Average	238	123	127	86	48.4	46.7	63.9

Degree of Septicization of the Akron Sewage and of the Effluents of the Three Preparatory Devices

On account of the relatively large quantities of dissolved oxygen in the crude Akron sewage, it was thought of interest to determine what may be called the "staling period," that is the period of retention in a settling tank before the complete exhaustion of the dissolved oxygen in the applied sewage. Such data are important, because, in comparing the efficiency of preparatory treatment, not only is the removal of suspended matter an important criterion, but also the degree of staling developed in the passage of the sewage through the tank. Other conditions being equal, it is apparent that an effluent will be better prepared for final treatment that combines a maximum suspended matter removal with a minimum degree of septicization.

To collect data bearing upon this question, from April 15 to June 27 inclusive, samples of the crude sewage and of the effluents of the preparatory tanks were incubated with the addition of methylene blue. Results of these tests,

shown in Table No. 17, clearly indicate the relative septicization of the effluents of the three preparatory devices. The decreased reducing time noted with the advent of warm weather, in the case of the Dortmund and septic tanks effluents, coincides with evidences of marked putrefaction in the sludge deposited in these tanks. It is interesting to note that the rate of deoxygenation of the effluent of the Imhoff tank was much slower during this same period, illustrating the advantage of the independent sludge compartment.

TABLE No. 17

Incubation Tests of Effluents of Preparatory Treatment Tanks and of the Crude Sewage, Illustrative of Relative Staling During Flow of Sewage Through the Different Tanks

Elapsed Time in Hours for Decolorization of Methylene Blue at Room Temperature

1912 Date	Crude Sewage	Effluent of		
		Imhoff Tank	Dortmund Tank	Septic Tank
April 15	17	17	17	10
19	36	36	22	38
May 3	2	4	4	4
5	20	20	20	20
11	7	27	22	22
12	17	17	17	7
15	21	21	21	14
18	13	26	26	24
20	16	20	17	4
23	7	7	3	6
24	5	3	1	2
26	5	6	6	6
27	4	3	3	4
30	11	12	7	4
31	12	14	12	5
June 3	14	12	12	5
5	10	14	12	8
6	5	9	6	2
7	7	5	5	3
8	8	9	8	8
9	22	21	10	5
10	4	4	4	3
12	8	4	3	5
14	6	4	3	3
16	12	6	6	3
18	21	4	6	4
19	18	6	4	3
20	8	4	3	3
21	24	11	6	2
22	4	3	4	2
25	5	5	5	5
26	5	3	4	2
27	7	4	4	3

SLUDGE DISPOSAL STUDIES

With reference to sludge disposal, it was deemed of interest and importance to learn whether storage of sludge from the Imhoff and Dortmund tanks in a separate compartment outside of the tank would result in loss of water and reduction in volume, and whether fermentation and putrefaction would continue to develop after the sludge had been removed from the tanks.

To this end, on July 23, there were placed in the sludge tank 1.86 cubic yards of Imhoff tank sludge, and, on the following day, 1.22 cubic yards of Dortmund tank sludge, a total of 3.08 cubic yards. The sludge was allowed to stand in the tank exposed to the weather.

On August 19, the volume of the sludge was found to be 1.53 cubic yards, a reduction of nearly 50 per cent. On September 10, the measured volume of sludge was 1.77 cubic yards. The initial depth of the sludge column was 4 feet. During the studies but little fermentation was noted in this sludge. In view of the marked changes in density it is evident that the reduced volume is to be attributed to compacting. These interesting data are tabulated in the following table.

TABLE No. 18

Results of Sludge Storage Studies

Sludge in tank, July 24 (cubic yards)	3.08
Sludge in tank, Aug. 19 (cubic yards)	1.53
Sludge in tank, Sept. 10 (cubic yards)	1.77

Analyses of Sludge

1912 Date	Elapsed Time, Days	Per Cent. Water	Specific Gravity	Weight Per Cu. Yd. (Tons)
July 24.....	0	80.0	1.08	0.911
Aug. 19	27	67.6	1.16	0.979
Sept. 10.....	49	65.4	1.17	0.987

Measurements of the quantity of sludge in the tank during the experiment were made by carefully observing the average depth of the supernatant liquid above the solid deposit.

Summary

For conclusions regarding the type of preparatory treatment adaptable to Akron conditions, as developed by these tests, reference should be made to the final summary and conclusions at the end of this report.

PARTIAL VIEW OF TESTING STATION, SHOWING SPRINKLING FILTERS

SPRINKLING FILTERS

The three sprinkling filters studied at the station are typical of the devices in use at a number of the larger cities in this country and abroad for the removal of dissolved impurities from settled sewage. Briefly stated, a sprinkling filter consists of a bed of stones or other hard material broken to a size ranging from one to two and a half inches, onto the surface of which sewage is applied in finely divided condition. A large sprinkling filter in action resembles a lawn on which a number of sprinklers are in operation.

The application of the sewage as a fine spray permits the constant presence of air in the filtering material. The oxygen so introduced is then taken up by the bacteria in removing the putrescible matters from the applied sewage. Typical plants are in operation at a number of American cities, notably, Columbus, Baltimore, Reading and Atlanta.

Character of Applied Sewage

Two of the test units operated at the station received the effluent from the Imhoff tank, the other from the Dortmund tank. It will be recalled that Filter No. 1 contained five feet of broken sewer pipe or chuck; Filter No. 2, to which was applied the effluent of the Dortmund tank, contained five feet of broken stone; and Filter No. 3 contained five feet of broken lime stone (in the latter part of the tests, this depth was increased to six feet).

Distribution

Sewage was distributed over the surfaces of the filters by means of Taylor nozzles throwing a circular spray. The average head under which the nozzles was operated was 5 feet.

Rates of Treatment

For reasons already mentioned, the areas of each of the three filters were considered equal, that is, 145 square feet, or 0.0033 acre. Based upon the observed discharge of sewage from the several preparatory devices there were calculated the rates of treatment on the sprinkling filters in terms of million gallons per acre in 24 hours. As will be noted from the operation data shown below, the rates of treatment on the sprinkling filters were changed from time to time during the tests. This was effected by reducing the size of the orifice in the sprinkling nozzle. Unless the entire station was shut down for repairs or other reasons, the sprinkling filters were operated continuously. Practically speaking, the filters were in service for about 90 per cent. of the period covered by the tests. The net rates of operation of the three sprinkling filters were about 2,000,000 gallons per acre in 24 hours.

Sampling Schedule

In general, the sampling schedule for the sprinkling filters was the same as that for the crude sewage and the effluents from the preparatory treatment devices. Composite samples consisted of equal portions collected at hourly intervals during the sampling day. Until August 25, special samples for dissolved oxygen were collected on days when chemical analyses were made.

After the above date, dissolved oxygen samples were collected daily. Until July, chemical samples were collected from the effluents of the filters themselves, but from July to the end of the tests, chemical analyses were made of samples collected from the settling basins.

Results Accomplished

The object of sprinkling filter treatment is the modification of the dissolved organic matters in the applied sewage to an extent such that the effluent will be stable, and, if discharged into a stream under summer conditions, will give rise to no nuisance attributable to putrefactive decomposition. The results of the analyses of the three sprinkling filters operated at the station, particularly as regards the organic matter, as indicated by the organic nitrogen, nitrogen as free ammonia, and oxygen consumed, show that the effluents from these filters contain much less of the above constituents than were present in the applied sewage. To determine the efficiency of a sprinkling filter in producing a stable effluent, there has been devised a test which indicates the rate at which oxygen will be absorbed by the organic matters remaining in the effluent, when stored for a definite time at room temperature. The results of this determination are recorded in the analyses, as relative stability. The test is made with the undiluted effluent and also with a dilution of 1:1 with fully aerated river water. A relative stability of 95 indicates that the organic matters of the applied sewage have been sufficiently reduced by the filters to prevent putrefactive decomposition.

The extent to which the different sprinkling filters remove the organic matter of the applied sewage is shown in the next table, which is computed from the detailed analyses of the effluents from these devices. It will be noted that there is a progressive increase in the removal or the modification of the organic constituents of the applied sewage as the period of service of the filter increased. In other words, a certain time is necessary for the establishment of the biological processes within the filter, essential for producing a stable effluent. This table shows the net rates of operation, the total number of samples collected, the percentage removal of the several constituents of the applied sewage, and the relative stability of the effluents under a dilution of 1:1 of river water. Toward the end of the tests, the relative stabilities of the diluted effluents for the three filters were 88, 89 and 92, respectively, indicating that all three of the filters were doing satisfactory work. Improved methods of distribution would, no doubt, have caused the filters to show such results earlier than was true in the case of these test devices.

TABLE No. 20

Percentage Removal by Sprinkling Filters or Settling Basins of the Constituents of the Applied Sewage

1912 Month	Net rate Millions of Gallons per Acre per day	Total number of Average Samples of Effluents	Per Cent. Removed				
			Oxygen Consumed	Nitrogen as Organic	Nitrogen as Free Ammonia	Suspended Matter	Relative Stability 1:1
Filter No. 1							
April	2.4	13	4.0	–7.5	–20.7	52.0	..
May	2.4	14	15.0	7.7	–13.8	49.6	..
June	2.3	11	35.6	35.6	20.7	63.3	25
Settling Basin No. 1							
July	2.1	8	46.0	56.8	18.8	73.8	38
August	2.1	11	52.6	56.8	24.0	74.8	65
September	2.1	4	56.4	52.4	30.9	65.5	88
Filter No. 2							
May	2.7	3	18.5	4.0	17.9	47.0	*
June	2.2	11	35.7	5.7	27.0	28.8	–55
Basin No. 2							
July	2.0	8	44.2	56.3	9.1	72.7	48
August	2.0	11	54.0	55.6	35.9	82.7	78
September	2.0	4	57.2	70.0	42.7	88.7	89
Filter No. 3							
May	2.3	3	22.5	–2.7	20.6	49.2	..
June	2.2	11	37.7	38.8	24.0	56.6	25
Basin No. 3							
July	2.0	8	47.4	49.4	27.7	75.9	53
August	2.0	11	55.0	56.8	37.3	75.8	88
September	2.0	4	57.7	56.1	35.8	77.2	92

*Started May 27, 1912.

TABLE No. 21

Percentage Removals by Sprinkling Filters Referred to Crude Sewage, Combined Efficiency of Preparatory Treatment and Sprinkling Filters or Settling Basins

1912 Month	Net Rate Millions of Gallons Per Acre Per Day	Total Number of Average Sample of Effluents	Per Cent. Removed				Relative Stability 1:1
			Oxygen Consumed	Nitrogen as Organic	Nitrogen as Free Ammonia	Suspended Matter	
Filter No. 1							
April	2.4	13	16.3	6.5	–23.1	73.6	.....
May	2.4	14	26.2	27.0	–25.0	74.9	.....
June	2.3	11	42.0	48.7	12.5	78.4	25
Basin No. 1							
July	2.1	8	49.4	65.3	15.5	80.0	38
Aug.	2.1	11	58.3	71.2	11.0	87.6	65
Sept.	2.1	4	59.4	62.9	13.8	84.6	88
Filter No. 2							
May	2.7	3	29.6	36.9	12.8	76.0	.....
June	2.2	11	44.0	42.7	18.8	72.0	55
Basin No. 2							
July	2.0	8	44.2	59.5	7.7	78.8	48
Aug.	2.0	11	56.1	63.9	21.8	81.9	78
Sept.	2.0	4	57.1	67.6	21.5	85.1	89
Filter No. 3							
May	2.3	3	29.6	36.2	10.2	75.1	.....
June	2.2	11	44.0	51.3	16.2	74.5	25
Basin No. 3							
July	2.0	8	49.4	59.4	24.7	81.6	53
Aug.	2.0	11	60.5	71.1	26.6	88.0	88
Sept.	2.0	4	60.5	65.7	20.0	87.9	92

Based upon the analyses of the crude sewage, the three sprinkling filters removed respectively, in September, 59.4, 57.1 and 60.5 per cent. of the oxygen consumed; 62.9, 67.6 and 65.7 per cent. respectively, of the organic nitrogen; and, 84.6, 85.1 and 87.9 per cent., respectively, of the suspended matter. The rates of treatment of the three filters were substantially the same. Conditions with respect to distribution were alike and the variables were the kind of filtering material and the character of the applied sewage. Since the analyses of the effluents from the Imhoff and Dortmund tanks are substantially alike, it seems proper to consider that, excepting the increased depth of Filter No. 3 in the latter part of these tests, the only variation in the three test sprinkling filters is the character of the filtering medium.

Suspended Matter

The finely divided suspended matters in the sewage applied to sprinkling filters are, in large part, retained in the filter by the gelatinous zoogloeal coating which develops upon the filtering material. The stones retain considerable suspended matter, but, in course of time, the filtering material is overloaded and large quantities of suspended solids, usually of a granular nature, escape with the effluent. Such a phenomenon is usually spoken of as unloading. A study of the analyses of the suspended matter in the effluents of the sprinkling filters indicates that during the tests there was but little or no unloading, and that a considerable part of the suspended matter was stored within the filter. The average, maximum, and minimum results of suspended matter determinations, expressed as parts per million, and tons per million gallons, together with the average percentages of removal, are shown in Table No. 23. Comparison of these results with the action of sprinkling filters in practice indicates that the test devices were not operated long enough to obtain the unloading condition observed in large plants in the spring and fall.

TABLE No. 22

Suspended Matters in Effluents of Sprinkling Filters

Filter Number	Number of Samples	Parts per Million			Tons per Million Gallons			Average Per Cent. Removed
		Max.	Min.	Avg.	Max.	Min.	Avg.	
1	38	131	34	61	0.55	0.14	0.25	54.3
2	14	170	35	79	0.71	0.15	0.33	32.7
3	14	177	31	73	0.74	0.13	0.31	55.0

Relative Stability of Settled Effluents

The important function of sprinkling filters, as previously stated, is to so alter the organic matters in the applied sewage that, in the effluents from the filters, putrefactive decomposition will no longer take place. The extent to which such a result is accomplished is determined by the relative stability test as already described. Table No. 23 shows interesting data regarding the relative stability of effluents from the three sprinkling filters. It is of interest to note the gradual increase in the relative stability as the period of operation increased.

TABLE No. 23

Relative Stability of Settled Sprinkling Filter Effluents

1912 Date	Relative Stability No Dilution			Relative Stability Dilution 1 : 1		
	Filter 1	Filter 2	Filter 3	Filter 1	Filter 2	Filter 3
June 28.....	20	31	20	28	35	21
" 29.....	10	25	8	25	55	25
July 6.....	3	8	7	20	25	20
" 7.....	12	25	18	24	57	60
" 8.....	12	95	75	23	95	95
" 9.....	8	15	40	28	35	43
" 10.....	7	18	25	21	36	32
" 11.....	8	15	27	25	40	45
" 12.....	12	15	34	28	35	65
" 13.....	7	38	8	20	62	52
" 15.....	10	27	20	18	38	30
" 17.....	8	15	10	25	29	40
" 18.....	8	18	12	42	39	35
" 19.....	32	62	44	45	95	95
" 20.....	18	70	40	31	95	95
" 21.....	8	30	29	23	39	35
" 23.....	6	10	28	22	31	31
" 24.....	20	32	95	28	48	95
" 28.....	24	95	95	95	95	95
" 29.....	30	35	65	53	50	95
" 31.....	..	12	32	..	65	69
Aug. 1.....	23	9	55	30	52	55
" 2.....	24	25	95	37	47	95
" 3.....	37	22	80	95	95	95
" 5.....	32	45	80	35	95	95
" 6.....	34	42	68	65	75	95
" 7.....	36	49	60	78	75	95
" 8.....	32	30	50	59	80	78
" 9.....	68	45	95	95	95	95
" 10.....	40	48	45	72	95	90
" 12.....	27	35	60	65	85	95
" 13.....	27	36	95	44	72	95
" 14.....	23	30	68	52	80	95
" 15.....	29	38	65	71	65	95
" 17.....	24	29	60	71	75	95
" 19.....	95	95	75	95	95	95
" 22.....	20	28	64	70	42	80
" 24.....	41	47	64	52	95	95
" 26.....	97	95	95	97	95	95
" 27.....	95	95	95	95	95	95
" 28.....	41	80	95	95	95	95
" 29.....	45	68	95	95	95	95
" 30.....	80	60	68	95	72	95
" 31.....	40	58	70	50	95	95
Sept. 1.....	95	95	95	95	95	95
" 2.....	95	95	95	95	95	95
" 3.....	95	95	95	95	95	95
" 4.....	95	95	95	95	95	95
" 5.....	60	60	58	80	95	72
" 6.....	75	85	70	80	95	95

TABLE No. 23 (Continued)

Relative Stability of Settled Sprinkling Filter Effluents

Date 1912	Relative Stability No Dilution			Relative Stability Dilution 1:1		
	Filter 1	Filter 2	Filter 3	Filter 1	Filter 2	Filter 3
Sept. 7.....	80	60	65	95	85	95
" 8.....	95	95	95	95	95	95
" 9.....	95	95	95	95	95	95
" 10.....	95	95	95	95	95	95
" 11.....	42	60	75	95	95	95
" 12.....	30	35	60	65	60	95
" 13.....	60	95	72	95	95	95
" 14.....	65	95	45	72	60	95
" 15.....	62	30	95	95	45	95
" 16.....	95	95	95	95	95	95
" 17.....	95	95	95	95	95	95
" 18.....	72	81	55	95	95	95
" 21.....	55	64	95	85	82	95
" 22.....	72	95	95	72	95	95

Dissolved Oxygen

Recent studies have shown that the dissolved oxygen in the effluents of sprinkling filters is of marked importance with respect to the ultimate stability of the effluent. All stable effluents contain dissolved oxygen in considerable quantities. In fact, the sprinkling filter process depends for its success upon the constant presence of air (oxygen) within the pores of the filtering material. If oxygen is absent from the interior of the sprinkling filters, there develops a class of bacteria which thrives in the absence of air, a class to which are attributed many of the phenomonæ of putrefaction. In Table No. 24 is shown, by months, the per cent. saturation of dissolved oxygen in the effluents of the sprinkling filters or settling basins, for the period covered by the tests. Per cent. saturation means the per cent. that the oxygen in the effluent bears to the oxygen required for complete saturation of water at a given temperature. Obviously, the lower the temperature of water, the greater the quantity of oxygen required for saturation.

The comparatively low dissolved oxygen results indicate the effect of clogging and non-uniformity of distributions with nozzles operated under a constant head. In practice, more uniformity of distribution, obtained by varying the head, would, no doubt, result in more thoroughly aerated effluents.

TABLE No. 24

Per Cent. Saturation of Dissolved Oxygen in Effluents of Sprinkling Filters

Month 1912	Filter Nos.			Period of Operation
	1	2	3	
May	49	42	40	No. 1, April 15 to Sept. 13
June	35	41	36	
July	25	32	32	No. 2, May 27 to Sept. 13
August	36	35	43	
September	41	47	46	No. 3, May 27 to Sept. 13

Aerial Nuisance

In large sprinkling filter plants, operated with fixed sprays similar to those used in these tests, the spraying of the sewage into the air, at times, gives rise to marked odors which, in some instances have been borne by the wind for perhaps a mile from the plant. Ordinarily, however, but little odor nuisance is noticeable more than a quarter of a mile from a sprinkling filter plant. The question of odors, when settled sewage is sprayed into the air, depends, of course, upon the relative staleness of the sewage, that is, the relative degree of putrefaction of the dissolved organic matters. Under Akron conditions, as has been discussed, there was no marked septicization in the effluents from any of the preparatory devices. On this account there was practically no nuisance from odors from the three test filters. In fact, 25 feet from the three filters, no appreciable odor could be observed.

Flies

With the advent of warm weather, there developed on the surfaces of the three sprinkling filters large numbers of small insects belonging to the fly family. These pests have been noted frequently at large purification plants of the sprinkling filter type, and belong to a genis known as psychoda. The flies are very small, and can easily pass through an ordinary window screen. They do not fly far from the surface of the filters and unless caught by a storm, do not travel far from the plant. At the first signs of a storm, the flies crawl into the upper layers of the filtering material. In some places, these insects have caused marked annoyance to operators, and special screens are necessary to keep them out of dwellings and other structures located near the plant.

It is probable that the flies, together with worms and other infusoriae, assist largely in the conversion of the organic matters of the applied sewage to relatively stable humus. Frequently, large masses of fly larvae were noted on the under side of the top stones on the filters.

Operation of Sprinkling Filters

Under ordinary conditions, sprinkling filters are operated on an on-and-off schedule. The precise procedure at a given plant depends on local conditions

with respect to the character of applied sewage, and the locally determined optimum schedule. At times, the filters are operated on alternate weeks; again, operated six days, and rested on the seventh. Sometimes, filters are operated continuously for several weeks, and then are rested for a varying period. In starting the Akron tests, it was originally planned to rest the filters one day in seven, but, owing to the uncontrollable shutdowns of the plant, it was decided to operate the filters continuously, as previously stated.

Nitrification

Nitrification is a term applied to the effect of a certain class of bacteria upon organic matters, and refers particularly to the relative quantities in the effluent of oxygen in the form of nitrates and nitrites. In sewage work, nitrification is indicative of thorough aeration, and generally of more or less thorough modification of the organic matters to stable form. Nitrification is dependent upon the presence of oxygen in the depths of the filter, and poor nitrification shows that an insufficient supply of air has been furnished for proper purification.

The organisms which produce nitrification are found in sewage, and, in course of time, develop upon the surface of the filtering material. The rate of development depends upon temperature and aeration conditions. Filters placed in service in the cold winter months require longer for developing nitrification than those started in the heat of summer. References to the results of analyses of the effluents of the sprinkling filters shows that no material nitrification occurred until after two months' operation, that is, during August and September. At times, there was practically no nitrification in the effluents of any of the filters, a feature possibly due to surface clogging and inferior aeration in the main body of the filter. No doubt, in a practical plant operating with the Akron sewage under improved conditions for distribution, nitrification in sprinkling filters would be much higher.

Special Features of Nozzle Operation

Throughout the tests more or less clogging occurred in the nozzles through which the sewage was applied to the sprinkling filters. The clogging was largely due to pieces of rubber so fine as to escape sedimentation in the preparatory devices.

Clogging was less serious in the nozzle fed from the Imhoff tank than that to which was applied sewage from the Dortmund tank. The latter nozzle eventually clogged so frequently that a screen constructed of ordinary wire cloth, such as is used for window screens, was placed around the outlet pipe from the tank. This device very successfully prevented further clogging, showing that the troublesome shreds of rubber can readily be removed by proper screens. It is to be stated that clogging from the rubber wastes was more serious during the period of active fermentation in the sludge in the Dortmund tank. Since the Imhoff tank effluent was not effected by sludge putrefaction, less clogging was observed in the nozzle which received the effluent from this tank.

It is evident from these tests that these finely divided shreds of rubber must be removed before the sewage is applied to sprinkling filters. Inasmuch as there are but two plants from which rubber wastes are discharged into the city sewers, it would probably be more practical and cheaper to provide means for removing these matters at the mills, than at the municipal sewage purifica-

tion works, where it would be necessary to operate a relatively fine screen through which would pass the settled sewage of the entire city.

For the first few days sewage was applied to filter No. 1 through a 9-16-inch Columbus nozzle. The orifice in the Columbus nozzle is much larger than the annular space in spindle nozzles, and clogging was not so serious.

In the latter part of the tests, there developed in the tops of the dome around the orifices of the nozzles gelatinous growths, the effect of which was a material decrease in the rate of discharge. To remove the growth, the nozzles were taken apart, and the orifices scraped with a special curved edge tool. In a practical way, these growths could, no doubt, be prevented by the application of hypochlorite to the effluent of the preparatory devices.

Clogging and Pooling

Observations were made throughout the tests regarding the operation of the sprinkling filters with respect to any features of importance in operation, in case such devices should be included in a sewage plant for the City. In many instances, sprinkling filters, after continuous operation for some time, become clogged on the surface with the result that the sewage stands thereon in pools. This feature, of course, to a large extent, precludes the entrance of oxygen into the main body of the filtering material. At times, also, especially in winter, there develops on sprinkling filters, extensive algal growths which also serve to impair aeration.

With the test devices, there was very little evidence of clogging or pooling, and no algal growths developed. It will be recalled that experience in practice has shown that pooling and clogging and, incidental thereto, the development of algae on the surface of sprinkling filters are rarely observed in the summer months. In case algal growth develops on the surface of sprinkling filters, it can readily be controlled by the application of strong solutions of hypochlorite of lime, as has been thoroughly studied and developed at the Sewage Testing Station of the Sanitary District of Chicago. The application of this chemical does not in any way interfere with the processes of purification that take place within the filters.

Condition of Filters When Dismantled

At the close of the tests, the filters were completely dismantled and the filtering material was carefully examined. The deposits of organic matter and all clogged filtering material was confined to the zone to which the sewage was actually applied. A deposit of gray suspended matter, extending downward about 18 inches, was observed on the surface of the stones, but not, of course, sufficient to fill the voids. Below this point, the stone filtering material was relatively clean, although it contained small flakes of brownish granular suspended material.

In the case of the chuck filters, the accumulation was noted for a depth of 30 inches below the surface of the filter. It was noticeable that upon those particles of chuck which happened to be placed with the concave surface upward, there was a much heavier deposit than that noted in the stone filters. In this connection, it is to be recalled that the chuck filter was operated about 43 days longer than either of the stone filters. But little material was found deposited upon the vitrified convex surfaces of the pieces of chuck. It is interesting to record that the pieces of chuck with convex surfaces uppermost

afforded better shelter for the flies than the particles of broken stone. Many more flies, especially at the approach of a storm, were observed on the surfaces of the chuck than on those of the stone filters.

Sedimentation of Sprinkling Filter Effluents

The tendency of accumulations of organic matter which cling to the stones in a sprinkling filter gradually to become oxidized, and eventually to peel off and escape with the effluent, has been mentioned in discussing the feature of suspended matters. At times of marked peel-off, the effluent from sprinkling filters may contain several tons of dry solids per million gallons. In certain cases, it is desirable to prevent the entrance of these solid matters into a stream. Frequently, these suspended particles contain considerable unstable organic matter and develop serious sludge deposits in the stream adjacent to the plant. By the provision of small settling basins of a capacity equal to a period of flow of about 2 hours, it is possible to reduce the suspended matters in the average effluent of a sprinkling filter to the vicinity of 25 or 30 parts per million, about 0.1 ton (dry) per million gallons.

Careful measurements were made of the sludge deposits in the settling basins subsidiary to each of the sprinkling filters. Analyses were also made to determine the character of the organic matters still remaining in the deposit.

During the first 2 months of operation, settling basins Nos. 1, 2 and 3 accumulated respectively, 2.2, 3.1 and 2.6 cubic yards of wet sludge per million gallons, corresponding to 0.095, 0.357 and 0.204 ton of dry solids. In the latter period of operations, the accumulations in these basins were very much greater, and were, respectively, 5.3, 5.05 and 5.94 cubic yards, or 0.47, 0.45 and 0.53 ton of dry solid matter per million gallons. Since these results covered but a relatively short period it is probable that the annual deposits in these basins would be much less than these figures indicate.

It is noteworthy that in the latter period filter No. 3 unloaded more suspended matter than either of the 5 foot filters. The data on sludge accumulation in the settling basins are shown in Table No. 25.

TABLE No. 25

Sludge Deposition in Settling Basins

	Basin Nos.		
Period May 26 to July 29.	1	2	3
Cubic yds. of wet sludge	0.99	1.32	1.10
Volume of effluent, million gallons	0.441	0.424	0.425
Cubic yds. of wet sludge per million gallons	2.2	3.1	2.6
Per cent. water	95.0	87.0	91.0
Specific gravity	1.02	1.05	1.06
Tons dry solid matter per million gallons	0.095	0.357	0.204
Period July 30 to August 26.			
Cubic yds. of wet sludge	1.08	0.95	1.13
Volume of effluent, million gallons	0.203	0.188	0.180
Cubic yds. wet sludge, per million gallons	5.3	5.05	5.94
Per cent. water	89.7	89.7	89.7
Specific gravity	1.03	1.03	1.03
Tons dry solids per million gallons	0.47	0.45	0.53

It is to be stated in connection with the above that the basins used at the testing station were very shallow, a condition which would be overcome at a large plant by deeper construction and by providing a sloping bottom. Experiences elsewhere have shown that violent fermentation can be largely controlled by constructing the basins in accordance with the Dortmund or Imhoff plan, in which cases the pressure of the water column above the sludge tends to confine the gas, and prevent violent upheavals.

As shown by the analytical data, the basins reduced the suspended matter in the sprinkling filter effluents to an average of 25 or 30 parts per million. The results of 6 analyses of the sludge from the 3 basins (Table No. 26) show that, under local conditions, these deposits contained considerable unoxidized organic matter. The deposits were black, and had a strong odor, while granular, they did not have the appearance of well oxidized sediment from thoroughly matured sprinkling filters. The high percentage of nitrogen in these deposits is worthy of special comment. In Table No. 26, an analysis of Dortmund tank sludge is shown for purposes of comparison.

TABLE No. 26

Analyses of Sludge Deposited in Settling Basins

Date	Basin No. 1		Basin No. 2		Basin No. 3		Dortmund Tank Average
	July 29	Aug. 26	July 29	Aug. 26	July 29	Aug. 26	
Weight of wet sludge per cubic yds. in tons.....	.861	.869	.886	.869	.894	.869	0.920
Specific gravity	1.02	1.03	1.05	1.03	1.06	1.03	1.09
Per cent. water	94.5	89.7	87.1	89.7	91.2	89.7	78.6
Per cent. dry solids	5.5	10.3	12.9	10.3	8.8	10.3	22.4
Volatile matter (dry basis)	33.0	30.4	25.0	30.4	28.3	30.4	42.9
Nitrogen (dry basis)....	2.64	1.84	1.44	1.84	1.60	1.84	0.83
Fats (dry basis).....	5.4	4.0	4.4	4.0	4.3	4.0	5.8

Rates of Operation and Stability of Effluents

The efficiency of sprinkling filters in the treatment of sewage depends on a number of factors, chief of which are the rates of treatment and the depth and character of the filtering material. Ordinarily, sprinkling filters may be expected to furnish satisfactory purification of the sewage of from 20,000 to 25,000 persons per acre. The optimum depth of such filters is usually about 6 feet. It has been found in practice that the stability of the effluent, the degree of aeration, the extent of nitrification, and, in general, the continued establishment of aerobic conditions within the filtering material are largely dependent upon the gross and net rate at which the sewage is applied to the filter. Bearing on the efficiency of sprinkling filters, there is also the important feature of the thoroughness of the distribution of the applied sewage. For large plants, particularly in the United States, distribution is usually afforded by some type of nozzle through which the sewage is applied to the surface of the filtering material in a finely divided state.

In the case of the test devices, the rate of operation was initially fixed at 2,500,000 gallons per acre in 24 hours gross, as it was thought possible that the Akron sewage could satisfactorily be treated at this rate. As the tests progressed, and the results from the sprinkling filters were not so satisfactory as desirable, the rate of operation was reduced to about 2,000,000 gallons per acre in 24 hours. The efficiency of the test filters and the discussion regarding them should be considered with respect to the above rate.

In reviewing the work of the sprinkling filters tested at the station, it is to be noted that Filters Nos. 1 and 3 received the thoroughly settled effluent from the Imhoff tank. The results of the operation of these two filters thus afford an opportunity, up to the time an additional foot of stone was added to No. 3, for the comparison of broken stone and chuck on an equal basis, as regards rate, depth, and character of effluent. A study of the results indicates that the stone and chuck gave practically equal results as regards quantitative efficiency, but, with respect to operation, there appears to be considerable advantage in favor of the broken stone. This refers particularly to the concavity of the pieces of chuck, and to the penetration of organic matter.

The results obtained from Filter No. 3 at the increased depth (6 feet) were much superior to the results in Filter No. 1, and to those obtained from Filter No. 3 before the depth of stone was increased. Filter No. 2, also constructed of broken stone to a depth of 5 feet, received the effluent from the Dortmund Tank. It will be recalled that, with the advent of warm weather, marked fermentation developed in the sludge deposited in this tank, with the result that the removal of suspended matter was very low. Furthermore, dissolved oxygen practically disappeared from the effluent, and evidences of marked septic action were observed over the surface of the liquid in the tank. The effect of this, no doubt, was greatly to impair the aeration in Filter No. 2, as was verified later by the large accumulation of sludge in the upper layers of this filter. The efficiency of Filter No. 2 was much less than that of either of the other two.

Summary

Akron sewage settled by preparatory treatment can be successfully treated by sprinkling filters constructed of crushed stone placed to a depth of 6 feet, when operated at a net rate of 2,000,000 gallons per acre in 24 hours. A head of 5 feet will be required for operating the spray nozzles.

The effluent from the filters should be settled in basins holding 2 hours flow and preferably provided with a separate sludge compartment, or means for the frequent withdrawal of sludge. The effluent from these basins will be practically stable per se., entirely stable when diluted with equal parts of river water, and will cause no objectionable conditions in the Cuyahoga River below the purification works at the minimum stages of this stream.

On account of greater clogging and deeper penetration of organic matters, broken sewer pipe is not so satisfactory as crushed stone as a filtering medium. Filters of stone will require less frequent cleansing and removal of filtering media than if constructed of broken sewer pipe.

To minimize nozzle clogging, the wastes from the rubber mills must be passed through fine screens before admitted into the city sewers. The manufactural wastes of the city did not interfere with the bacterial processes upon which depends the successful treatment of the Akron sewage by sprinkling filters.

CONTACT FILTERS

A contact filter consists of a bed of stone, cinders, or other hard material placed to a depth of from 3 to 5 feet in a water-tight basin. The size of the filtering material varies somewhat, and ordinarily ranges from ¼ to 1 inch or more in diameter. Suitable valves are provided for controlling the flow of the sewage from the tank. In operation, sewage is admitted until the pores of the filtering material are completely filled with liquid. The inflow is then shut off and the liquid in the filter is allowed to stand in contact with the filtering material. After a short period of standing full, the out-let valve is opened and the liquid is allowed slowly to drain out.

By bacterial activities and the effect of worms and other forms of lower animal life, the dissolved impurities in the applied sewage are more or less thoroughly oxidized or modified to stable form. A contact filter differs materially from a sprinkling filter, especially as regards the method of operation. Much less head is required than is true of sprinkling filters. As it seemed possible that contact filters would be adapted to Akron conditions, two filters of this type were studied at the station.

Voids

When first placed in service, careful determinations were made of the voids, that is the open space between the particles of filtering material. Filter A, of broken sewer pipe showed 46 per cent., and Filter B, of stone 38 per cent.

Operating Data

The contact filters were flooded with the effluent of the Imhoff tank applied through a 2-inch iron pipe, which terminated at the surface of the filtering material. No special provisions were made in these small units for distributing the applied sewage. The period of filling was regulated to about 4 hours. The filters were allowed to stand full 4 hours, at the end of which time the valve controlling the discharge was opened, and the filters were allowed a draining or emptying period of 4 hours. Since the filters were flooded but once in 24 hours, the aeration period was about 12 hours.

Based upon the above schedule of operation, the rates of treatment were, respectively, 740,000 and 615,000 gallons per acre in 24 hours.

The contact filters were not placed in service until June 13, as it was not possible to complete their construction before this time. After about 8 weeks' operation, samples were collected for chemical analysis. The composite samples consisted of equal portions collected at 20-minute intervals during a discharge period and mixed to form a composite.

Results Accomplished

Ordinarily, a well matured contact filter provides such modification of the dissolved organic matters in the applied sewage that the effluent approximates a state of ultimate stability. The effluents are usually quite low in suspended matter. A study of the results of the analyses of the contact filter effluents, shown in the appendices, brings out the fact that up until the end of the tests the locally operated filters did not satisfactorily remove the organic matters of the applied sewage. It will be noted that there was but little change in the organic nitrogen and free ammonia, although the oxygen consumed

was reduced about 25 and 45 per cent. in Filter A and Filter B, respectively, illustrating the absorptive effect generally observed in contact filters. The analyses further show that the effluents from both filters were generally unstable, practically free from nitrites and nitrates. The fact that small quantities of dissolved oxygen were observed is attributable to oxygen introduced into the effluent drain during the period of draining.

The analyses indicate that a large part of the suspended matters applied to the filters was retained in the filtering material, illustrating a clogging feature frequently noted in contact filters. That this condition was pronounced in the local filters, attributable to the lack of maturity and proper aerating conditions within the filters, was clearly shown when they were dismantled at the close of the tests. The filtering material in both filters was choked with sludge, indicating a deficiency of aeration.

Summary

For 3 months two filters of the contact type were operated at the testing station. These filters did not afford satisfactory purification. Clogging was largely in evidence, aeration was imperfect, and stable effluents were not obtained.

FINAL SUMMARY AND CONCLUSIONS

It is now purposed to review briefly, in a non-technical manner, the leading results obtained during these investigations. The subjects are discussed in the same order as in the main body of the report.

The Akron Sewage

The composition of the local sewage was learned from 103 analyses consisting of 2,616 portions collected hourly day and night, during the tests. This sewage is representative of the entire sewage of the city and was pumped from a manhole in the 42-inch outfall sewer. During storms, large quantities of clay and sand are carried by the sewage, but, ordinarily, the analyses show the Akron sewage to be chiefly of domestic origin and of moderate strength.

The sewage contained unusually large quantities of salt, termed chlorine in the tables, corresponding to 6.28 tons of pure salt per million gallons. The suspended solids averaged 238 parts per million, by weight, equivalent to practically one ton of dry material for each one million gallons.

Industrial Wastes

Of the industrial wastes of the city, only those from the rubber reclaiming plants, the salt works, and breweries flow into the city sewers. The others enter the river or the canal. None of these latter wastes, at present, cause objectionable conditions, and should such occur in the future, dredging operations in the river, or in the canal, or settling tanks constructed at the mills, might be desirable. For short periods there were in evidence at the sewer outfall relatively large volumes of strong manufactural wastes, but it is a fact, shown conclusively by these tests, that in the general average the industrial wastes of the city do not materially affect the normal composition of the local sewage, nor prevent its successful final treatment on filters.

The Testing Station

Methods deemed best adapted to the treatment of the local sewage were studied for a period of eight and one-half months at a testing station located along the Ohio Canal near Lock No. 16. On an average, 50,000 gallons of sewage were pumped in each 24 hours into tanks and filters representative of preparatory and final treatment procedures. The results of these tests were determined by chemical analyses, and for such work there was provided a fully equipped chemical laboratory.

Preparatory Treatment

Those procedures, by which there is removed from sewage as large a proportion of the suspended matters as is capable of removal by subsidence, within economical limits, are termed preparatory treatments. Such results are usually secured by passing the sewage into tanks where these solids may have an opportunity to gravitate to the bottom. The deposited matters are known as sludge. At the testing station, in addition to a small tank for removing sand, there were studied three devices for preparatory treatment, differing essentially from each other in design and operation, and representative of current procedures in practice. The devices tested are respectively known as Imhoff, Dortmund and septic tanks. The first two were circular in form, and the last was rectangular. The Imhoff tank had a conical bottom, was about 16 feet deep, of such capacity that 2.3 hours were required for the sewage to flow from the inlet to the outlet, and contained a separate compartment for sludge. The Dortmund tank also had a sloping bottom, a capacity of about 2.7 hours' flow, but no means for storing the sludge apart from the flowing sewage. The septic tank was a level basin, about 8 feet deep and of about 7.4 hours' capacity. All of these tanks were open to the air.

Under a velocity of about 60 feet per minute, there was removed by the grit chamber 0.2 ton of sand per million gallons of sewage treated. It was found practical to retain in the Imhoff and Dortmund tanks about 50 per cent. of the suspended matters in the crude sewage, or 0.5 ton of dry solids per million gallons. The septic tank removed on an average of 63.9 per cent. of the suspended solid matter. Its efficiency and that of the Dortmund tank was greatly impaired by fermentation and upheavals in the deposits in these tanks. Under like conditions of operation, the efficiency of the Imhoff tank was much superior.

Preparatory Treatment in Relation to Sludge Accumulation and Disposal

The operation of devices for removing suspended solids from sewage involves proper means for disposing of the sludge, which is the term applied to such depositions. Sludge is a black semi-solid mass containing from 75 to 95 per cent water, and, when thoroughly decomposed, it is substantially free from odor.

It was shown by the tests that during the summer months it would be necessary to remove the sludge from the Dortmund and septic tanks at frequent intervals, in order to prevent large masses of previously deposited sludge, under the active fermentation incident to warm weather, from rising to the surface, escaping with the effluent, and clogging the sprinkling filters.

Although circumstances might be such that sludge could be removed from the tank and disposed of without difficulty as often as necessary, yet, it is

more frequently true that sludge must be held in a tank to await favorable weather conditions, for, otherwise, the disposal of the sludge would create very objectionable conditions. It must be borne in mind that in wet weather sludge disposal on sludge beds is attended with difficulty, and that unless it is possible to take advantage of the dilution afforded by a stream in flood stages, it is necessary to hold the sludge in the tanks to await drying weather.

It follows from the above facts that not only must the settling tanks be of such construction that the removal of suspended matter will be high, but also they must be of such design as to prevent the contamination of the flowing sewage by putrefaction in the stored sludge.

Such provision is an essential feature of the design of the Imhoff tank, and results obtained during these tests substantiate these claims. The efficiency of the tested unit was nearly 50 per cent. and the sludge was more readily drained, more thoroughly digested, and less offensive than that from either the Dortmund or the septic tank. Furthermore, in the deep separate sludge compartment, sludge could be stored for 4 months or longer with no detrimental effect upon the removal of suspended matter.

The evidence obtained during these tests clearly shows that tanks of the Imhoff type are readily adaptable to local conditions, and when operated in conjunction with sludge drying beds will provide more satisfactory removal of suspended matter, and a better solution of the sludge problem than tanks designed in accordance with the Dortmund or septic tank principle.

The tests show that the period of flow in the upper compartment of Imhoff tanks for Akron may be about 2.5 hours. It will be necessary to provide for an average net accumulation of about 2.3 tons of wet sludge per million gallons.

Details of sludge wells, sludge drying beds, and other features of construction are not within the province of these tests.

PROCESSES FOR REMOVING DISSOLVED IMPURITIES

Processes for Removing Dissolved Impurities

The removal of the dissolved impurities in sewage is accomplished by filters of different types. Sprinkling filters and contact filters have proved successful in large plants in practice, and as possibly adaptable to the Akron problem, representative test units were operated at the station.

Sprinkling Filters

Briefly stated, a sprinkling filter consists of a bed of coarse stone, or other hard material, placed to a depth of 5 feet or more, and provided with suitable drain pipes.

To the top of the filter, sewage is applied in a finely divided state by spraying through fixed nozzles, which, when in operation, have the appearance of lawn sprinklers. Purification is effected by natural bacterial agencies which destroy the dissolved impurities by the aid of the oxygen in the pores of the filtering material.

In the local tests, the relative advantages of broken stone and broken sewer pipe in filters were especially studied. These test filters were 13 feet 7 inches in diameter, and 5 feet and 6 feet deep.

It was found that the local sewage could be satisfactorily treated by sprinkling filters, when operated at a rate of 2,000,000 gallons per acre in 24 hours. Suspended solid matters were discharged from these filters equivalent to an average deposition of from 2.5 to 5.0 cubic yards per million gallons, or about 0.5 ton of dry solid matter for each million gallons. It is necessary to settle the effluents of these filters in basins holding about 2 hours' flow, preferably provided with a separate sludge compartment, or other means for frequent cleansing. The sludge can be readily dried on special sludge beds. The effluent from these basins when diluted with equal parts of river water, a dilution possible for the entire sewage of the city even under the minimum flow in the Cuyahoga River, was not subject to further putrefactive decomposition.

Stone and broken sewer pipe of the same depth gave practically equal results. At 6 foot depth, the stone filter was much superior. Improvements in means for spraying the sewage would, no doubt, result in higher efficiencies than were observed during these tests. No objectionable odors were noted near the filters when in operation.

The tests showed that the glazed surfaces of broken sewer pipe do not appear to be sufficiently rough to afford proper support for the organic films essential to most efficient results. Although the first cost of broken sewer pipe might be less than that of stone, the tests show that this advantage will be outweighed by increased difficulties of operation, for it is clearly evident that filters constructed of broken sewer pipe will require more frequent cleaning and renewal than filters of broken stone.

It was further developed that the wastes from the rubber reclaiming plants must be screened to prevent the excessive clogging of the filter nozzles by small pieces of rubber.

Contact Filters

Contact filters consist of water tight basins provided with suitable inlet and outlet valves and containing from 3 to 5 feet of hard, weather resisting material, crushed, ordinarily, to a size ranging from ½ to 2½ inches and over. In operation the pores of the filter are filled with sewage, and after a short time, the outlet is opened and the liquid is allowed slowly to drain out. In contradistinction to sprinkling filters, during operation the sewage stands in contact with the filtering medium, the voids of which are completely filled with liquid. During the above cycle of operations, the dissolved impurities in the sewage are largely destroyed by the agencies of bacteria and other organisms.

The evidence obtained during these tests strongly indicates that, under local condition, contact filters operated at a rate of 600,000 gallons per acre in 24 hours cannot successfully purify the settled Akron sewage. Should engineering features indicates the necessity for contact filters in conjunction with settling tanks, the evidence strongly supports the view that satisfacory results could be secured only by providing secondary filters to supplement the work of the primary units.

PLAN RECOMMENDED

These tests have clearly shown that the sewage of the City of Akron can successfully be purified at a plant which would comprise:

1. A small grit chamber for the removal of sand.
2. Imhoff tanks of a capacity equivalent to a period of flow of about 2.5 hours, and sludge beds corresponding to an average net accumulation of about 1.4 tons of dry solids per million gallons. (Drying period—July 1st to Nov. 1st.)
3. Sprinkling filters operated at the rate of 2,000,000 gallons per acre in 24 hours, and small settling basins of about 2 hours' flow, with ample means for the withdrawal of sludge.
4. Adequate means for the disposal of an accumulation in the settling basins of about 0.5 ton of dry solid matter per million gallons.

The evidence is conclusive that such a plant would purify the sewage of Akron in a most thorough manner, and under continued proper operation and efficient supervision, would prevent all visible contamination of the Cuyahoga River below the outlet of the Akron sewers.

Respectfully submitted,

HARRY B. HOMMON,
Chemist and Director of Testing Station.

ANALYSES OF SEWER AIR

In the summer of 1911, a serious explosion occurred in the trunk sewer on North Howard Street, followed in the fall by a second explosion which did much damage to store windows and store fronts on Howard Street between Mill and Cherry Streets.

At the request of the Director of Public Service, a series of analyses was made of the air in the trunk sewer to determine the cause of these explosions. Separate investigations were made in March and June of 1912, and were confined to the trunk sewer in that section of the city where the explosions occurred.

Samples of air were collected by aspiration from the bottom of the trunk sewer, directly below manholes. These samples were analyzed with a Moorehead Gas Apparatus, and in accordance with standard methods. The constituents determined were carbon dioxide, carbon monoxide, illuminants, methane, and nitrogen. The results of the analyses are shown in the next table in which is stated the points at which these samples were collected. For comparison, the table includes an analysis of normal air.

The results show that the air in the sewer differs but little from normal air, and that there were no constituents to which the explosion could be attributed. It is probable that the explosions were caused by the ignition of gasoline or of other volatile hydrocarbons originating from garages or dry cleaning establishments. The possibility of explosions from gasoline discharged into the sewers is considerable, and some of the larger cities, notably, New York, Chicago, Pittsburgh and Philadelphia, have rigid ordinances which provide that sewer connections from garages and dry cleaning establishments, or, in general, from all establishments that use gasoline or other volatile hydrocarbon oils shall be trapped between the building and the sewer. It would be desirable as a means of preventing possible explosions,, due to gasoline and other volatile oils, that there be prepared and passed a similar ordinance for the City of Akron.

TABLE No. 27

Analyses of Air in Bottom of Manholes of Trunk Sewer

Location of Manhole	Date 1912	Per Cent. Carbon Dioxide	Per Cent. Illuminants	Per Cent. Oxygen	Per Cent. Carbon Monoxide	Per Cent. Methane	Per Cent. Nitrogen
Cherry and Howard Sts.	3-5	0.2	0.2	19.0	.....	0.0	80.6
Cherry and Howard Sts.	3-5	0.4	0.2	18.8	0.2	0.0	80.4
Market and Howard Sts. ...	3-8	0.4	0.0	19.6	0.2	0.0	79.8
Market and Howard Sts. ...	3-8	0.6	0.2	19.2	0.0	0.0	80.0
Mill and College Sts.	3-12	0.2	0.2	19.2	0.2	0.0	80.2
Telephone Conduit, Mill and College Sts.	3-12	0.4	0.2	19.6	0.2	0.0	79.6
North and Howard Sts. ...	6-20	.....	0|2	19.8	.....	0.0	80.
Ridge and Howard Sts. ...	6-25	0.2	0.2	19.2	.02	0.0	80.2
Howard, North and Federal Sts.	6-25	0.6	0.0	19.0	.....	0.0	80.4
Howard, North and Federal Sts.	6-25	.....	0.2	19.2	.....	0.0	80.6
Market and Howard Sts. ...	6-26	0.2	0.2	19.0	0.2	0.0	80.4
Cherry and Howard Sts. ...	6-26	0.8	.....	19.0	0.2	0.0	79.0
Mill and Howard Sts. ...	6-26	0.8	0.2	19.0	0.2	0.0	79.8
Quarry and Main Sts.	6-26	0.6	.....	19.0	.....	0.0	80.4
Mill and College Sts.	6-27	0.2	0.2	19.3	.....	0.0	80.3
Mill and College Sts.	6-27	0.4	0.2	18.8	.....	0.0	80.6
Normal Air	.....	.....	.....	20.7	.....	.....	79.3

LIST OF APPENDICES

Appendix A. Detailed Results of Chemical Analyses of Crude Sewage.

Appendix B. Detailed Results of Chemical Analyses of Effluent of Imhoff Tank.

Appendix C. Detailed Results of Chemical Analyses of Effluent of Dortmund Tank.

Appendix D. Detailed Results of Chemical Analyses of Effluent of Septic Tank.

Appendix E. Detailed Results of Chemical Analyses of Influent and Effluent of Contact Filter A.

Appendix F. Detailed Results of Chemical Analyses of Influent and Effluent of Contact Filter B.

Appendix G. Detailed Results of Analyses of Influent and Effluent of Sprinkling Filter No. 1.

Appendix H. Detailed Results of Analyses of Influent and Effluent of Sprinkling Filter No. 2.

Appendix I. Detailed Results of Analyses of Influent and Effluent of Sprinkling Filter No. 3.

Appendix J. Device for Measuring Supernatant Liquid over Sludge.

Appendix K. Curve Plotted to Show Per Cent. Saturation and Parts per Million of Dissolved Oxygen in Water of Various Temperatures on the Fahrenheit and Centigrade Scale.

Note:—For the Results of Analyses of the Influents to the Preparatory Tanks, see Analyses of Crude Sewage for Corresponding Dates.

APPENDIX A

Detailed Results of Chemical Analysis of Crude Sewage

Result of Chemical Analysis of Crude Sewage

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as				Oxygen Consumed			Chlorine	Suspended Matter			Alkalinity in terms of $CaCO_3$	Dissolved Oxygen*
		Organic		Free Ammonia	Nitrites	Total	Dissolved	Suspended		Total	Volatile	Fixed		
		Total	Dissolved											
May 1...	13	12.0	.....	6.5	0.16	81	.....	....	548	159	104	55	210	.....
" 3...	16	12.0	.....	6.5	0.14	96	.....	....	598	298	178	120	240	.....
" 4...	15	12.0	.....	7.5	0.16	86	.....	....	573	111	65	46	230	.....
" 11...	16	12.0	.....	6.5	0.14	84	.....	....	548	247	106	141	250	.....
" 13...	12	11.0	.....	6.0	0.16	88	.....	....	523	280	139	141	250	41
" 14...	14	13.0	.....	7.5	0.14	77	.....	....	598	191	113	78	250	.....
" 15...	15	12.0	.....	8.0	0.14	90	.....	....	523	433	169	264	250	.....
" 16...	14	12.0	.....	6.5	0.12	96	.....	....	548	180	93	87	250	30
" 17...	15	9.3	.....	8.0	0.14	76	.....	....	623	171	88	83	230	31
" 18...	15	11.0	.....	6.5	0.16	75	.....	....	598	257	169	88	250	29
" 20...	15	12.0	7.1	7.0	0.12	71	60	11	648	183	122	61	230	28
" 22...	17	9.5	5.4	7.0	0.14	97	77	20	623	209	151	58	250	11
" 24...	18	13.0	.....	7.5	0.14	193	165	28	698	321	213	108	420	39
" 25...	18	10.0	6.1	8.0	0.18	88	74	14	623	245	174	71	280	26
" 27...	17	13.6	8.8	8.5	0.16	93	77	16	648	221	143	78	260	11
" 29...	18	10.0	7.6	6.5	0.18	83	69	14	598	161	101	60	230	44
" 31...	17	12.0	8.0	8.5	0.16	.....	.....	....	648	281	184	97	220	41
Average ..	16	11.5	7.1	7.2	0.15	92	87	17	598	232	136	96	253	30

*Per cent. saturation.

Result of Chemical Analysis of Crude Sewage

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as				Oxygen Consumed			Chlorine	Suspended Matter			Alkalinity in terms of $CaCO_3$	Dissolved Oxygen*
		Organic		Free Ammonia	Nitrites	Total	Dissolved	Suspended		Total	Volatile	Fixed		
		Total	Dissolved											
June 4.....	18	11.0	6.9	8.0	0.16	.....	....	....	648	316	186	130	290	....
" 5.....	19	9.2	.....	6.5	0.14	84	....	....	673	213	145	68	270	....
" 8.....	18	13.0	.....	8.0	0.20	98	....	....	673	275	182	93	290	28
" 11.....	17	11.0	8.5	8.0	0.12	126	102	24	698	382	259	123	290	20
" 13.....	19	12.2	7.4	7.5	0.12	118	102	16	698	289	167	122	300	21
" 19.....	20	14.2	7.8	9.5	0.20	89	70	19	698	199	132	67	220	36
" 21.....	21	6.9	3.7	8.0	0.16	99	91	8	723	343	186	157	290	26
" 22.....	20	13.3	8.5	8.0	0.12	78	57	21	723	223	136	87	260	19
" 25.....	21	14.4	6.9	8.5	0.16	114	89	25	748	295	193	102	300	21
" 27.....	23	11.7	6.1	8.0	0.14	108	82	26	773	528	340	188	260	21
" 29.....	22	11.0	6.9	8.0	0.18	82	48	34	773	311	185	126	250	16
Average	20	11.7	7.0	8.0	0.15	100	80	22	711	307	192	115	275	23

*Per cent. saturation.

Result of Chemical Analysis of Crude Sewage

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as Organic Total	Nitrogen as Organic Dissolved	Nitrogen as Free Ammonia	Oxygen Consumed Total	Oxygen Consumed Dissolved	Oxygen Consumed Suspended	Chlorine	Suspended Matter Total	Suspended Matter Volatile	Suspended Matter Fixed	Alkalinity in terms of $CaCO_3$	Dissolved Oxygen*
July 7.....	23	9.1	5.9	9.0	48	32	16	1697	109	68	41	240	.....
" 9.....	24	11.0	7.4	7.5	108	86	22	1947	264	145	119	260	14
" 10.....	25	11.0	8.2	7.5	88	70	18	2073	258	157	101	260	17
" 18.....	26	10.0	.....	7.0	91	.....	.....	1073	226	143	83	220	12
" 21.....	22	9.0	6.6	7.5	46	27	19	573	187	68	119	180	.....
" 23.....	25	11.0	5.1	9.0	106	80	26	598	460	219	241	290	.....
" 28.....	23	8.8	5.6	8.5	45	29	16	523	116	54	62	230	14
" 29.....	23	12.0	7.9	7.0	94	70	24	548	356	227	129	320	10
" 30.....	23	8.8	7.2	6.5	100	81	19	573	272	184	88	220	.....
Average	24	10.1	6.7	7.7	81	59	23	1067	250	141	109	249	13

*Per cent. saturation.

Result of Chemical Analysis of Crude Sewage

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as					Oxygen Consumed			Chlorine	Suspended Matter			Alkalinity in terms of $CaCO_3$	Dissolved Oxygen*
		Organic		Free Ammonia	Nitrites	Nitrates	Total	Dissolved	Suspended		Total	Volatile	Fixed		
		Total	Dissolved												
Aug. 1..	23	13.0	6.1	8.0	0.16	0.62	120	89	31	573	390	186	204	310	00
" 5..	22	8.4	6.0	6.5	0.16	0.40	96	76	20	2073	256	156	100	250	20
" 8..	23	12.0	6.5	6.0	0.08	0.69	95	71	24	2273	301	149	152	280	.....
" 11..	21	11.0	4.7	7.0	0.08	1.00	40	22	18	698	257	49	208	190	.....
" 13..	23	11.0	6.7	5.0	0.12	0.68	86	70	16	1773	192	126	66	210	22
" 15..	23	13.0	7.1	7.0	0.12	0.51	127	108	19	1598	270	195	75	280	26
" 19..	23	14.0	7.0	6.0	0.10	0.60	76	58	18	1748	210	151	59	240	7
" 22..	23	11.0	7.0	7.0	0.14	0.29	98	64	34	673	261	154	107	260	13
" 24..	23	5.9	3.5	5.0	0.12	0.25	77	60	17	573	148	103	45	270	24
" 27-28	23	11.0	7.3	6.0	0.12	0.47	89	70	19	1548	324	134	190	270	26
" 29-30	22	12.0	5.2	6.5	0.12	0.33	102	88	14	1823	237	108	129	230	31
Average	23	11.1	6.1	6.4	0.12	0.53	91	71	20	1391	259	138	121	254	19

*Per cent. saturation.

Result of Chemical Analysis of Crude Sewage

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as					Oxygen Consumed			Chlorine	Suspended Matter			Alkalinity in terms of $CaCO_3$	Dissolved Oxygen*
		Organic		Free Ammonia	Nitrites	Nitrates	Total	Dissolved	Suspended		Total	Volatile	Fixed		
		Total	Dissolved												
Sept. 3-4..	23	9.4	6.2	5.5	0.14	0.80	85	66	19	1698	221	125	96	220	22
" 5-6..	24	9.5	.....	7.0	0.18	0.42	94	...	...	1648	212	122	90	220	19
" 9-10..	23	10.0	10.0	6.5	0.12	0.14	92	73	19	1273	236	157	79	240	14
" 12-13..	23	13.0	7.1	7.0	0.18	0.28	93	76	17	1298	191	131	60	240	15
Average	23	10.5	7.7	6.5	0.15	0.41	91	72	18	1419	215	134	81	230	18

*Per cent. saturation.

APPENDIX B

Detailed Results of Chemical Analyses of Effluent of Imhoff Tank

Result of Chemical Analysis of Effluent of Imhoff Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as		Oxygen Consumed	Chlorine	Suspended Matter		
		Total Organic	Free Ammonia	Total		Total	Volatile	Fixed
Feb. 13	11	9.2	6.5	79	1598	.....	.....	.....
" 14	12	11.0	6.5	86	2198	.....	.....	.....
" 15	11	8.1	6.0	88	1798	76	40	36
" 16	11	7.1	7.0	81	1648	88	66	22
" 17	11	5.1	9.0	78	2048	76	60	16
" 18	9	4.8	8.5	43	1848	54	30	24
" 19	8	3.9	6.0	64	1348	92	44	48
" 20	8	8.9	6.0	88	1498	150	50	100
" 21	8	7.1	3.0	58	2248	76	24	52
Average	10	7.2	6.5	74	1804	87	45	42

Result of Chemical Analysis of Effluent of Imhoff Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as			Oxygen Consumed			Chlorine	Suspended Matter			Alkalinity in terms of $CaCO_3$
		Total Organic	Free Ammonia	Nitrites	Total	Dissolved	Suspended		Total	Volatile	Fixed	
March 12.....	9	13.0	6.0	.....	91	....	....	288	92	48	44	231
" 13.....	9	11.0	6.5	0.04	82	....	....	358	100	44	56	250
" 14.....	9	5.1	9.0	.....	90	....	....	358	134	44	90	240
" 15.....	6	12.0	6.0	0.08	82	....	....	408	116	26	90	210
" 17.....	8	8.0	4.5	.....	23	....	....	528	80	30	50	200
" 19.....	.....	5.5	7.0	.....	69	....	....	458	66	38	28	250
" 20.....	10	9.3	8.0	.....	91	....	....	448	80	36	44	230
" 21.....	7	8.6	5.5	.....	80	....	....	408	64	46	18	210
" 22.....	9	10.0	6.5	.....	91	88	3	508	122	44	78	260
" 23.....	10	13.0	6.5	.....	76	....	....	488	168	74	94	200
" 25.....	7	8.9	6.0	0.09	78	....	....	448	84	36	48	210
" 26.....	9	10.0	6.5	.....	84	73	11	548	86	30	56	190
" 27.....	9	9.4	5.5	0.07	73	62	11	1348	76	18	58	190
" 28.....	10	8.6	5.5	0.10	70	....	....	1848	136	42	94	170
" 29.....	8	6.6	3.5	0.12	70	....	....	1248	116	28	88	160
" 30.....	9	8.6	5.5	0.11	67	....	....	1598	98	66	32	190
Average	9	9.2	6.1	0.09	76	75	8	705	101	41	60	212

Result of Chemical Analysis of Effluent of Imhoff Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as			Oxygen Consumed	Chlorine	Suspended Matter			Alkalinity in terms of $CaCO_3$
		Total Organic	Free Ammonia	Nitrites	Total		Total	Volatile	Fixed	
April 1.....	9	8.9	6.0	.....	70	548	104	12	92	180
" 2.....	8	5.3	4.0	0.13	64	398	76	14	62	160
" 3.....	7	9.6	4.5	0.12	66	598	116	48	68	190
" 5.....	11	9.6	4.5	0.13	.....	698	53	29	24	190
" 7.....	8	7.6	6.5	0.60	.....	748	52	19	33	160
" 9.....	12	9.4	5.5	0.17	65	448	57	28	29	220
" 10.....	12	9.7	6.0	0.13	69	848	60	31	29	220
" 11.....	12	8.1	6.0	0.12	74	1448	74	43	31	220
" 12.....	13	9.7	6.0	0.14	73	1898	79	42	37	180
" 13.....	13	13.0	8.0	0.16	70	1398	101	41	60	250
" 14.....	12	7.6	6.5	0.14	74	1348	103	18	85	180
" 15.....	12	6.9	4.0	0.16	60	1148	221	134	87	170
" 16.....	13	6.7	5.0	0.18	60	1398	87	40	47	190
" 17.....	12	8.0	4.5	0.12	65	498	111	36	75	180
" 18.....	13	9.9	5.0	0.16	75	298	72	39	33	200
" 19.....	12	11.0	5.5	0.18	81	348	174	142	32	220
" 20.....	13	.....	.....	.....	.....	348	78	43	35	230
" 21.....	11	15.0	6.0	0.16	41	348	46	25	21	160
" 22.....	13	13.0	3.8	0.14	75	398	84	43	41	210
" 23.....	13	15.0	2.7	0.14	88	398	90	57	33	230
" 24.....	14	11.0	6.5	0.12	88	423	147	90	57	240
" 25.....	14	12.0	6.0	0.14	79	473	125	74	51	230
" 26.....	14	11.0	7.0	0.16	94	448	136	67	69	280
" 27.....	14	.....	8.5	0.20	88	548	158	93	65	300
" 29.....	12	.....	.....	.....	72	.....	165	45	120	.....
" 30.....	12	8.3	5.0	0.16	.....	448	146	76	70	190
Average	12	9.8	5.5	0.17	72	716	104	51	53	207

Result of Chemical Anaysis of Effluent of Imhoff Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as			Oxygen Consumed	Chlorine	Suspended Matter			Alkalinity in terms of $CaCO_3$	Dissolved Oxygen*
		Total Organic	Free Ammonia	Nitrites	Total		Total	Volatile	Fixed		
May 1.....	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" 3.....	16	10.0	8.0	0.16	92	573	110	77	33	240	.....
" 4.....	15	10.0	8.0	0.14	89	598	102	65	37	270	.....
" 11.....	15	9.5	7.0	0.14	73	498	110	47	63	250	.....
" 13.....	13	8.7	7.0	0.14	78	573	104	47	57	240	56
" 14.....	14	17.0	8.0	0.14	72	573	117	69	48	230	63
" 15.....	15	10.0	8.0	0.12	83	548	148	68	80	250	.....
" 16.....	14	11.0	7.8	0.12	85	548	131	65	66	250	20
" 17.....	14	6.9	8.0	0.14	75	623	99	51	48	230	35
" 18.....	15	7.7	8.0	0.14	69	598	105	63	42	240	27
" 20.....	15	6.9	8.0	0.12	79	648	148	83	65	270	17
" 22.....	17	6.9	8.0	0.14	88	623	146	97	49	250	7
" 24.....	18	9.3	8.0	0.14	107	623	189	108	81	320	2
" 25.....	18	9.1	9.0	0.14	76	648	84	54	30	300	3
" 27.....	17	7.5	9.0	0.16	86	623	125	80	45	280	0
" 29.....	18	6.1	8.0	0.16	81	598	96	61	35	220	32
" 31.....	17	8.6	9.5	0.16	72	.....	103	61	42	.....	20
Average ..	16	9.1	8.1	0.14	82	593	120	68	52	256	23.5

*Per cent. saturation.

Result of Chemical Analysis of Effluent of Imhoff Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as				Oxygen Consumed	Suspended Matter			Dissolved Oxygen*
		Total Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed	
June 4....	19	5.9	9.0	0.12	0.34	81	105	59	46	0
" 5....	19	7.9	7.0	0.12	1.40	70	88	57	31	0
" 8....	18	7.0	9.5	0.10	0.48	76	116	73	43	0
" 11....	19	11.0	8.5	0.10	0.54	120	129	43	86	4
" 13....	19	11.0	8.0	0.12	0.74	98	215	127	88	11
" 19....	20	12.0	9.0	0.22	0.82	87	144	95	49	4
" 21....	21	8.5	8.0	0.14	.....	95	193	112	81	13
" 22....	21	11.0	9.0	0.16	0.73	78	204	116	88	0
" 25....	21	11.0	9.5	0.16	0.41	102	236	145	91	0
" 27....	24	5.7	9.5	0.16	0.38	94	162	103	59	0
" 29....	22	11.0	10.0	0.14	0.32	87	386	213	173	0
Average ..	20	9.3	8.8	0.14	0.62	90	180	104	76	3

*Per cent. saturation

Result of Chemical Analysis of Effluent of Imhoff Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as				Oxygen Consumed	Suspended Matter		
		Total Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed
July 7.....	23	7.8	9.5	0.16	0.22	48	131	77	54
" 9.....	24	7.7	8.0	0.14	0.25	91	140	77	63
" 10.....	25	9.0	7.5	0.20	0.24	88	261	154	107
" 18.....	26	11.0	7.5	0.14	0.45	99	309	184	125
" 21.....	22	6.1	8.0	0.24	0.45	49	237	107	130
" 23.....	25	9.1	9.0	0.18	0.33	121	209	116	93
" 28.....	23	7.2	8.5	0.22	0.09	35	96	45	51
" 29.....	23	7.3	6.0	0.12	0.54	81	146	80	66
" 30.....	23	5.5	6.5	.....	.....	98	124	73	51
Average	24	7.8	7.8	0.18	0.32	79	183	101	82

Result of Chemical Analysis of Effluent of Imhoff Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as				Oxygen Consumed	Suspended Matter		
		Total Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed
Aug. 1.....	23	9.3	8.0	0.14	0.35	109	140	80	60
" 5.....	21	6.4	8.5	0.14	0.16	93	120	74	46
" 8.....	23	7.9	7.0	0.10	0.45	77	118	60	58
" 11.....	21	7.1	7.0	0.12	0.41	31	102	27	75
" 13.....	23	6.3	7.0	0.12	0.37	70	122	77	45
" 15.....	23	8.5	8.0	0.16	0.25	91	134	87	47
" 19.....	22	8.0	8.5	0.12	0.22	60	121	75	46
" 22.....	23	8.5	8.0	0.18	0.12	84	143	82	61
" 24.....	23	3.6	6.5	0.12	0.10	89	150	93	57
" 27–28...	22	6.1	8.0	0.14	0.00	84	138	55	83
" 29–30...	22	10.0	6.5	0.14	0.14	87	115	61	54
Average	22	7.4	7.5	0.13	0.23	80	127	70	57

Result of Chemical Analysis of Effluent of Imhoff Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as				Oxygen Consumed	Suspended Matter		
		Total Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed
Sept. 3–4....	23	9.2	6.5	0.16	0.58	82	126	68	58
" 5–6....	24	7.7	8.0	0.20	0.25	90	104	65	39
" 9–10...	23	6.7	9.0	0.20	0.00	82	108	80	28
" 12–13...	23	9.1	9.0	0.18	0.23	86	119	78	41
Average	23	8.2	8.1	0.18	0.26	85	114	73	41

APPENDIX C

Detailed Results of Chemical Analyses of Effluent of Dortmund Tank

Result of Chemical Analysis of Effluent of Dortmund Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as		Oxygen Consumed	Chlorine	Suspended Matter		
		Total Organic	Free Ammonia	Total		Total	Volatile	Fixed
Feb. 13	10	9.2	6.5	80	1598	98	.....	.....
" 14	10	8.0	7.0	84	2248	94	.....	.....
" 15	11	9.7	6.0	87	1798	76	52	24
" 16	11	6.6	7.5	82	1598	84	70	14
" 17	10	4.8	8.5	74	1998	56	38	18
" 18	7	5.4	9.5	40	1848	56	42	14
" 19	7	2.8	5.5	65	1548	128	50	78
" 20	7	8.1	6.0	82	1398	78	50	28
" 21	8	8.9	2.0	58	2098	92	28	64
Average	9	7.1	6.5	72	1792	85	47	34

Result of Chemical Analysis of Effluent of Dortmund Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as			Oxygen Consumed		Chlorine	Suspended Matter			Alkalinity in terms of $CaCO_3$
		Total Organic	Free Ammonia	Nitrites	Total	Dissolved		Total	Volatile	Fixed	
March 12	9	12.0	6.0	.....	90	.....	288	116	64	52	240
" 13	9	10.0	8.0	0.04	83	.....	348	84	42	42	240
" 14	9	5.1	9.0	.....	91	.....	358	110	38	72	230
" 15	6	11.0	6.0	0.07	77	.....	428	100	18	82	210
" 17	8	8.0	4.5	.....	26	.....	538	108	34	74	210
" 19	.....	4.0	8.5	.....	69	.....	438	74	24	50	270
" 20	9	10.1	8.0	.....	88	.....	448	72	36	36	230
" 21	7	6.6	7.5	.....	80	.....	418	74	50	24	200
" 22	8	8.4	6.5	.....	86	.....	478	106	38	68	250
" 23	9	14.0	7.0	.....	78	.....	498	60	34	26	220
" 25	8	9.4	5.5	0.09	75	71	438	68	32	36	200
" 26	9	7.6	6.5	.....	84	78	538	108	36	72	200
" 27	9	8.9	6.0	0.08	74	63	1348	100	34	66	190
" 28	10	12.0	5.0	0.12	73	.....	1748	140	40	100	160
" 29	8	6.1	4.0	0.11	66	.....	1198	156	38	118	150
" 30	8	5.3	8.0	0.12	69	.....	1648	96	70	26	190
Average	8	8.7	6.6	0.09	76	71	697	98	39	59	212

Result of Chemical Analysis of Effluent of Dortmund Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as			Oxygen Consumed	Chlorine	Suspended Matter			Alkalinity in terms of $CaCO_3$
		Total Organic	Free Ammonia	Nitrites	Total		Total	Volatile	Fixed	
April 1	9	9.4	5.5	.....	68	898	106	34	72	170
" 2	8	8.5	4.0	0.12	65	398	60	12	48	160
" 3	7	8.0	4.5	0.12	69	648	110	44	66	190
" 5	11	10.0	4.0	0.13	.....	698	51	26	25	180
" 7	9	7.3	6.0	0.60	.....	648	87	30	57	160
" 9	12	9.7	6.0	0.13	70	598	74	40	34	230
" 10	12	8.1	6.0	0.13	72	798	87	55	32	220
" 11	12	8.9	6.0	0.13	76	1548	77	43	34	220
" 12	13	9.7	6.0	0.16	75	1898	.....	.....	.....	200
" 13	13	10.0	8.0	0.20	69	1448	90	38	52	250
" 14	12	7.9	7.0	0.14	55	1398	114	19	95	170
" 15	12	6.9	4.0	0.18	54	1148	129	35	94	160
" 16	13	7.2	4.5	0.14	63	1348	75	31	44	200
" 17	12	8.0	4.5	0.12	62	548	120	32	88	160
" 18	12	7.5	5.0	0.18	83	298	71	43	28	210
" 19	12	11.0	6.0	0.18	80	348	77	43	34	220
" 20	12	.....	.....	.....	.....	298	77	42	35	230
" 21	11	12.1	6.0	0.18	41	348	46	26	20	150
" 22	12	15.0	3.0	0.16	70	373	74	42	32	190
" 23	13	15.0	2.6	0.16	88	398	79	53	26	240
" 24	14	11.0	6.0	0.14	84	398	84	50	34	240
" 25	14	10.0	7.5	0.16	76	473	87	55	32	230
" 26	14	9.1	9.0	0.14	85	423	74	39	35	260
" 27	14	.....	9.0	0.14	86	523	70	42	28	280
" 29	12	.....	.....	.....	.....	.....	143	32	111	.....
" 30	12	8.1	6.0	0.14	74	448	85	47	38	190
Average	12	9.5	5.7	0.17	71	734	86	38	48	204

Result of Chemical Analysis of Effluent of Dortmund Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as			Oxygen Consumed	Chlorine	Suspended Matter			Alkalinity in terms of $CaCO_3$	Dissolved Oxygen*
		Total Organic	Free Ammonia	Nitrites	Total		Total	Volatile	Fixed		
May 1.....	14	10.0	6.5	0.14	101	523	159	118	41	260	.....
" 3.....	17	8.5	8.0	0.14	88	573	70	42	28	240	.....
" 4.....	16	9.3	8.0	0.12	89	573	77	33	44	270	.....
" 11.....	15	9.3	8.0	0.12	72	523	75	51	24	250	.....
" 13.....	13	8.2	7.5	0.12	75	548	92	44	48	240	.....
" 14.....	14	9.7	10.0	0.12	70	573	93	58	35	240	37
" 15.....	15	9.1	9.0	0.12	74	548	113	49	64	260	.....
" 16.....	14	9.0	7.5	0.10	80	548	91	48	43	240	17
" 17.....	15	5.1	9.0	0.10	74	648	74	39	35	240	34
" 18.....	15	7.9	7.0	0.12	65	598	78	47	31	250	23
" 20.....	15	6.9	8.0	0.12	76	623	96	57	39	260	14
" 22.....	17	6.4	8.5	0.12	80	623	108	77	31	270	5
" 24.....	18	8.5	8.0	0.12	90	648	103	69	34	290	18
" 25.....	17	8.1	10.0	0.10	80	648	91	58	33	240	0
" 27.....	17	6.7	9.0	0.14	82	623	100	63	37	290	0
" 29.....	18	7.9	7.0	0.10	78	598	104	63	41	230	23
" 31.....	17	8.9	9.0	0.16	69	.....	98	58	40	.....	16
Average	16	8.2	8.2	0.12	79	588	95	57	38	254	17

*Per cent. saturation.

Result of Chemical Analysis of Effluent of Dortmund Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as				Oxygen Consumed	Suspended Matter			Dissolved Oxygen*
		Total Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed	
June 4.....	19	5.9	9.0	0.10	0.48	79	122	71	51	0
" 5.....	19	6.6	7.5	0.12	0.64	69	100	68	32	....
" 8.....	18	9.1	9.0	0.10	0.45	76	106	67	39	0
" 11.....	19	6.7	9.0	0.10	0.46	112	141	84	57	0
" 13.....	19	8.8	8.5	0.14	0.57	90	139	79	60	8
" 19.....	20	3.5	9.0	0.20	0.69	82	128	86	42	2
" 21.....	21	5.3	8.0	0.14	.....	90	118	68	50	11
" 22.....	21	11.0	9.5	0.14	0.74	75	107	65	42	0
" 25.....	21	7.0	9.5	0.14	0.47	91	127	83	44	0
" 27.....	23	7.5	9.0	0.12	0.29	88	162	103	59	0
" 29.....	23	7.0	9.5	0.10	0.10	100	79	46	33	0
Average ...	20	7.1	8.9	0.13	0.49	87	121	75	46	2

*Per cent. saturation.

Result of Chemical Analysis of Effluent of Dortmund Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as				Oxygen Consumed	Suspended Matter			Dissolved Oxygen*
		Total Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed	
July 7.....	23	8.3	9.0	0.20	0.17	41	98	58	40	0
" 9.....	24	8.5	8.0	0.22	0.19	89	163	90	73	0
" 10.....	25	9.0	7.5	0.22	0.18	85	172	100	72	0
" 18.....	26	11.0	7.0	0.16	0.27	100	264	153	111	0
" 21.....	22	7.4	7.5	0.24	0.59	48	240	112	128	0
" 23.....	23	9.1	9.0	0.14	0.40	122	210	106	104	0
" 28.....	23	7.2	8.5	0.26	0.16	41	195	91	104	0
" 29.....	23	15.0	6.5	0.12	0.56	90	209	102	107	0
" 30.....	23	4.5	8.0	.....	.....	113	202	107	95	0
Average	24	8.9	7.9	0.20	0.32	81	195	102	93	0

*Per cent. saturation.

Result of Chemical Analysis of Effluent of Dortmund Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as				Oxygen Consumed	Suspended Matter		
		Total Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed
August 1	23	6.1	8.0	0.14	0.30	116	209	105	104
" 5	21	7.7	8.0	0.12	0.36	99	164	82	82
" 8	22	11.0	7.5	0.12	0.36	86	217	101	116
" 11	21	10.0	7.0	0.14	0.31	52	281	93	188
" 13	23	11.0	6.5	0.18	0.25	82	246	111	135
" 15	23	10.0	8.0	0.20	0.24	98	163	25	138
" 19	22	9.1	9.0	0.18	0.15	75	249	120	129
" 22	23	9.3	8.0	0.14	0.14	85	236	110	126
" 24	23	5.8	7.5	0.22	0.00	76	278	129	149
" 27-28	22	9.3	8.0	0.20	0.00	91	282	112	170
" 29-30	22	9.6	8.5	0.20	0.12	94	306	135	171
Average	22	9.0	7.8	0.17	0.20	87	239	102	137

Result of Chemical Analysis of Effluent of Dortmund Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as				Oxygen Consumed	Suspended Matter		
		Total Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed
September 3-4	23	11.0	7.5	0.38	0.58	87	254	115	139
" 5-6	24	8.3	9.0	0.12	0.16	96	246	120	126
" 9-10	23	8.6	9.5	0.24	0.00	90	304	171	133
" 12-13	23	13.0	9.5	0.26	0.34	91	333	185	148
Average	23	10.2	8.9	0.25	0.27	91	284	148	136

APPENDIX D

Detailed Results of Chemical Analyses of Effluent of Septic Tank

Result of Chemical Analysis of Effluent of Septic Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as		Consumed Oxygen	Suspended Matter		
		Total Organic	Free Ammonia	Total	Total	Volatile	Fixed
February 12	8	8.7	7.0	.....	90	.....	.....
" 13	10	8.2	7.5	77	70	.....	.....
" 14	11	9.2	6.5	71	68	.....	.....
" 15	11	7.6	6.5	78	46	34	12
" 16	11	5.4	9.5	76	74	54	20
" 17	10	4.8	8.5	76	58	36	22
" 18	7	5.1	9.0	40	60	40	20
" 19	7	3.3	6.0	60	84	32	52
" 20	7	6.5	6.0	78	44	36	8
" 21	8	8.7	3.0	57	82	24	58
Average	9	6.8	7.0	68	68	37	27

Result of Chemical Analysis of Effluent of Septic Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as			Oxygen Consumed		Chlorine	Suspended Matter			Alkalinity in terms of $CaCO_3$
		Total Organic	Free Ammonia	Nitrites	Total	Dissolved		Total	Volatile	Fixed	
March 10....	7	.....	.....	.....	.....	.....	348	.....	.....	.....	260
" 11....	7	.....	.....	.....	.....	.....	268	.....	.....	.....	230
" 12....	8	15.0	6.0	.....	73	.....	278	62	38	24	250
" 13....	9	10.0	8.0	0.04	82	.....	348	68	34	34	260
" 14....	9	7.1	7.0	0.07	87	.....	398	80	54	26	250
" 15....	7	7.9	7.0	.....	73	.....	318	108	14	94	210
" 17....	8	7.2	4.5	.....	26	.....	548	74	20	54	210
" 19....	.....	4.3	9.0	.....	65	.....	418	74	34	40	250
" 20....	9	8.5	8.0	.....	84	.....	458	44	22	22	230
" 21....	7	8.6	5.5	.....	80	.....	418	44	36	8	200
" 22....	8	7.6	6.5	.....	85	.....	478	84	32	52	230
" 23....	9	11.0	6.5	.....	78	.....	528	86	70	16	220
" 24....	7	.....	.....	.....	.....	.....	408	.....	.....	.....	130
" 25....	7	8.9	6.0	0.09	87	62	458	58	28	30	200
" 26....	9	8.6	5.5	.....	84	78	448	88	34	54	170
" 27....	8	8.1	6.0	0.09	70	59	1348	64	18	46	190
" 28....	10	9.4	5.5	0.11	68	.....	1748	94	30	64	170
" 29....	8	6.1	4.0	0.10	68	.....	1198	104	18	86	160
" 30....	8	7.8	5.5	0.11	68	.....	1648	56	52	4	190
" 31....	9	.....	.....	.....	.....	.....	1798	.....	.....	.....	182
Average	8	8.5	6.3	0.09	74	66	693	74	33	41	210

Result of Chemical Analysis of Effluent of Septic Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as			Oxygen Consumed	Chlorine	Suspended Matter			Alkalinity in terms of $CaCO_3$
		Total Organic	Free Ammonia	Nitrites	Total		Total	Volatile	Fixed	
April 1	9	8.1	6.0	.....	62	1048	88	26	62	180
" 2	8	6.1	4.0	0.12	62	398	70	14	56	150
" 3	8	8.0	4.5	0.12	67	598	74	32	42	170
" 5	11	8.8	4.5	0.18	.....	698	44	27	17	190
" 7	9	5.0	7.5	0.10	.....	698	64	40	24	190
" 9	10	11.0	6.5	0.19	60	598	39	24	15	220
" 10	12	8.1	6.0	0.14	66	698	50	26	24	210
" 11	12	7.8	5.5	0.14	69	1398	59	32	27	220
" 12	12	6.9	8.0	0.16	68	1848	62	30	32	210
" 13	13	11.0	7.5	0.18	64	1548	63	23	40	240
" 14	12	6.9	8.0	0.20	55	1448	78	15	63	220
" 15	12	7.2	4.5	0.24	52	1148	95	22	73	170
" 16	13	5.6	4.5	0.18	54	1348	63	28	35	190
" 17	12	6.7	5.0	0.12	54	648	92	26	66	180
" 18	12	7.5	5.0	0.18	85	298	54	30	24	220
" 19	12	11.0	6.0	0.18	78	348	63	35	28	210
" 20	13	.....	.....	.....	.....	348	65	35	30	230
" 21	11	12.0	6.0	0.18	42	298	45	24	21	150
" 22	12	15.0	3.0	0.20	60	373	59	32	27	200
" 23	12	15.0	2.7	0.16	83	398	73	44	29	220
" 24	14	10.0	6.5	0.16	79	398	57	34	23	220
" 25	14	10.0	6.5	0.14	70	448	67	46	21	220
" 26	14	11.0	6.5	0.16	86	448	57	32	25	270
" 27	15	.....	.....	0.18	83	523	65	39	26	300
" 30	12	7.3	6.0	0.18	68	448	85	48	37	190
Average	12	9.0	5.7	0.16	67	738	65	31	34	206

Result of Chemical Analysis of Effluent of Septic Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as			Oxygen Consumed	Chlorine	Suspended Matter			Alkalinity in terms of $CaCO_3$	Dissolved Oxygen*
		Total Organic	Free Ammonia	Nitrites	Total		Total	Volatile	Fixed		
May 1....	13	9.2	6.5	0.16	79	498	78	48	30	230	.....
" 3....	14	8.3	9.0	4.18	88	548	56	29	27	230	.....
" 4....	14	10.0	8.0	0.16	84	548	67	45	22	270	.....
" 11....	15	7.9	7.0	0.12	68	523	82	34	48	240	.....
" 13....	13	8.7	7.0	0.14	66	523	80	36	44	230	34
" 14....	14	12.0	7.5	0.14	69	573	80	44	36	250	40
" 15....	14	9.8	7.5	0.14	71	548	90	42	48	260	.....
" 16....	14	9.5	7.0	0.14	75	523	86	41	45	240	16
" 17....	15	4.8	8.5	0.14	71	623	59	29	30	230	34
" 18....	14	7.9	7.0	0.14	62	598	64	40	24	250	26
" 20....	14	6.1	8.0	0.14	64	623	76	44	32	250	11
" 22....	17	6.1	8.0	0.16	74	598	81	58	23	260	12
" 24....	18	6.7	9.0	0.16	82	623	79	55	24	280	14
" 25....	18	7.8	9.5	0.20	75	623	68	38	30	290	26
" 27....	16	6.9	8.0	0.20	70	623	76	46	30	270	0
" 29....	18	7.4	7.5	0.14	72	573	86	54	32	230	14
" 31....	17	8.0	8.5	0.16	58	.....	73	42	31	.....	13
Average ..	15	8.1	7.9	0.15	72	573	75	43	32	251	20

*Per cent. saturation.

Result of Chemical Analysis of Effluent of Septic Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as				Oxygen Consumed	Suspended Matter			Dissolved Oxygen*
		Total Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed	
June 4.....	19	7.5	9.0	0.12	0.27	69	67	35	32	0
" 5.....	19	7.4	7.5	0.20	0.19	67	62	41	21	0
" 8.....	18	7.6	11.0	0.12	0.18	74	70	45	25	0
" 11.....	18	6.4	8.5	0.14	0.42	86	100	53	47	0
" 13.....	19	7.7	8.0	0.16	0.48	82	80	44	36	4
" 19.....	20	7.3	10.0	0.14	0.19	73	77	50	27	2
" 21.....	21	3.5	9.0	0.14	.....	80	49	25	24	0
" 22.....	21	3.5	10.0	0.20	0.30	66	66	40	26	0
" 25.....	21	7.0	9.5	0.20	0.30	76	78	50	28	0
" 27.....	23	8.0	8.5	0.22	0.00	84	155	99	56	0
" 29.....	22	4.1	10.0	0.18	0.19	68	137	77	60	0
Average	20	6.4	9.2	0.17	0.25	75	86	51	35	0.5

*Per cent. saturation.

Result of Chemical Analysis of Effluent of Septic Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as				Oxygen Consumed	Suspended Matter			Dissolved Oxygen*
		Total Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed	
July 7.....	23	5.7	10.0	0.10	0.13	38	55	34	21	.....
" 9.....	24	6.7	9.0	0.10	0.07	78	91	55	36	0
" 10.....	25	7.9	7.0	0.18	0.04	33	92	55	37	0
" 18.....	25	7.7	8.0	0.18	0.07	83	81	56	25	0
" 21.....	22	5.8	7.5	0.28	0.20	39	81	36	45	0
" 23.....	24	8.6	9.0	0.12	0.28	113	103	54	49	0
" 28.....	23	5.6	8.5	0.10	0.05	28	84	42	42	0
" 29.....	23	6.3	7.0	0.20	0.39	68	84	47	37	0
" 30.....	23	9.2	6.5	.....	.....	86	137	80	57	0
Average	24	7.1	8.1	0.16	0.16	63	90	51	39	0

*Per cent. saturation.

Result of Chemical Analysis of Effluent of Septic Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as				Oxygen Consumed	Suspended Matter		
		Total Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed
August 1	23	9.3	8.0	0.20	0.07	87	99	52	47
" 5	21	6.7	9.0	0.10	0.10	86	104	61	43
" 8	23	8.5	8.0	0.12	0.24	70	112	58	54
" 11	21	8.5	8.0	0.20	0.22	39	130	40	90
" 13	23	9.3	8.0	0.16	0.01	68	110	59	51
" 15	23	9.1	9.0	0.08	0.16	83	148	73	75
" 19	22	6.6	11.5	0.06	0.12	62	154	73	81
" 22	23	11.0	10.0	0.04	0.18	81	169	82	87
" 24	22	5.0	7.5	0.04	0.16	70	169	85	84
" 27-28	22	11.0	9.5	0.18	0.00	83	231	92	139
" 29-30	22	9.6	8.5	0.18	0.00	86	170	79	91
Average	22	8.6	8.8	0.12	0.11	74	145	69	76

Result of Chemical Analysis of Effluent of Septic Tank

Parts per Million

1912 Date	Temperature Deg. C.	Nitrogen as				Oxygen Consumed	Suspended Matter		
		Total Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed
September 3-4	23	8.1	10.0	0.06	0.12	80	211	96	115
" 5-6	24	7.3	10.0	0.14	0.00	96	278	126	152
" 9-10	23	11.0	10.0	0.04	0.00	87	311	151	160
Average	23	8.8	10.0	0.08	0.04	87	266	124	142

APPENDIX E

Detailed Results of Chemical Analyses of Influent and Effluent of Contact Filter A

Detailed Results of Analysis of Influent and Effluent of Contact Filter A

1912 Date	Temperature Deg. C.			INFLUENT (Imhoff Tank)									EFFLUENT									
				Parts per Million									Parts per Million									
				Nitrogen as				Oxygen Consumed	Suspended Matter			Dissolved Oxygen*	Nitrogen as				Oxygen Consumed	Suspended Matter			Dissolved Oxygen*	Relative Stability
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed		Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed		
Aug. 15–16–17..	22	23	22	10.0	9.5	0.18	0.25	79	98	58	40	0	3.5	9.0	0.0	0.0	56	43	23	20	10	24
" 19–20.....	26	22	22	6.1	12.0	0.14	0.20	57	84	56	28	0	2.9	12.0	0.0	0.0	40	31	22	9	18	8
" 22–23.....	22	22	22	5.0	7.5	0.20	0.12	82	102	60	42	0	4.0	8.5	0.0	0.0	81	37	18	19	12	8
" 27–28–29..	18	22	20	9.7	10.0	0.14	0.12	90	131	74	57	0	3.7	12.0	0.0	0.0	70	46	26	20	18	18
Sept. 2–3–4....	24	23	22	6.5	10.0	0.16	0.58	56	122	50	72	0	2.1	12.0	0.0	0.02	36	38	17	21	17	11
" 9–10–11..	25	23	22	10.0	11.0	0.20	0.00	91	106	62	44	0	7.7	12.0	0.0	0.0	58	49	32	17	17	16
Average	23	22	22	7.9	10.0	0.17	0.21	76	107	60	47	0	4.0	10.9	0.0	0.003	57	41	23	18	15	14

*Per cent. saturation.

APPENDIX F

Detailed Results of Chemical Analyses of Influent and Effluent of Contact Filter B

Detailed Results of Chemical Analysis of Influent and Effluent of Contact Filter B

1912 Date	Temp'ture Deg. C.			INFLUENT (Dortmund Tank) Parts per Million									EFFLUENT Parts per Million									
				Nitrogen as				Oxygen Consumed	Suspended Matter			Dissolved Oxygen*	Nitrogen as				Oxygen Consumed	Suspended Matter			Dissolved Oxygen*	Relative Stability
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed		Organic	Free Ammonia	Nitrites	Nitrates	Total	Total	Volatile	Fixed		
Aug. 15–16–17.	22	23	22	11.0	10.0	0.16	0.24	94	302	146	156	0	2.5	6.0	0.0	0.0	51	38	20	18	9	18
" 19–20....	26	22	22	6.9	12.0	0.16	0.15	73	223	113	110	0	3.1	11.0	0.0	0.0	37	44	23	21	21	25
" 22–23....	22	24	22	6.9	8.0	0.20	0.12	55	149	73	76	0	2.3	7.0	0.0	0.0	42	24	10	14	20	22
" 27–28–29.	18	22	20	13.0	11.0	0.20	0.00	103	239	112	127	0	4.7	11.0	0.0	0.0	59	38	20	18	21	15
Sept. 2–3–4...	24	22	22	6.6	11.0	0.38	0.12	66	218	87	131	0	3.3	10.0	0.0	0.10	30	41	16	25	19	24
" 9–10–11.	25	22	22	8.5	12.0	0.24	0.05	91	153	82	71	0	4.5	8.0	0.0	0.07	43	46	21	25	29	32
Average	23	22	22	8.8	10.7	0.22	0.11	80	214	102	112	0	3.4	8.8	0.0	0.03	44	38	18	20	20	23

*Per cent. saturation.

APPENDIX G

Detailed Results of Analyses of Influent and Effluent of Sprinkling Filter No. 1

Results of Chemical Analysis of Influent and Effluent of Sprinkling Filter No. 1

1912 Date	Temperature Air, Deg. C.	INFLUENT (Imhoff Tank)							EFFLUENT								
		Parts per Million									Parts per Million						
		Nitrogen as			Oxygen Consumed	Suspended Matter			Gross Rate	Daily Yield in Mil.Gals. per A.	Nitrogen as			Oxygen Consumed	Suspended Matter		
		Organic	Free Ammonia	Nitrites		Total	Volatile	Fixed			Organic	Free Ammonia	Nitrites		Total	Volatile	Fixed
April 15.....	17	6.9	4.0	0.16	60	221	134	87	2.7	2.4	7.7	4.0	0.30	56	98	30	68
" 16.....	17	6.7	5.0	0.18	60	87	40	47	2.7	2.4	9.1	5.0	0.30	50	49	21	28
" 17.....	13	8.0	4.5	0.12	65	111	36	75	2.7	2.4	7.0	5.5	0.25	54	49	22	27
" 18.....	8	9.9	5.0	0.16	75	72	39	33	2.7	2.4	9.4	5.5	0.45	87	52	28	24
" 19.....	4	11.0	5.5	0.18	81	174	142	32	2.7	2.4	11.4	6.5	0.50	80	51	32	19
" 21.....	10	15.0	6.0	0.16	41	46	25	21	2.7	2.4	14.0	6.5	0.25	55	34	23	11
" 22.....	17	13.0	3.8	0.14	75	84	43	41	2.7	2.4	16.0	3.5	0.40	70	54	35	19
" 23.....	10	15.0	2.7	0.14	88	90	57	33	2.7	2.4	16.0	3.2	0.35	83	79	59	20
" 24.....	12	11.0	6.5	0.12	88	147	90	57	2.7	2.4	15.0	6.5	0.45	79	54	37	17
" 25.....	9	12.0	6.0	0.14	79	125	74	51	2.7	2.4	12.0	9.0	0.40	76	48	36	12
" 26.....	14	11.0	7.0	0.16	94	136	67	69	2.7	2.4	13.0	9.0	0.35	84	74	41	33
" 27.....	15	.....	8.5	0.20	88	158	93	65	2.7	2.4	.....	11.0	0.35	84	59	40	19
" 30.....	8	8.3	5.0	0.16	.....	146	76	70	2.7	2.4	7.4	7.5	0.30	73	68	34	34
Average	12	10.7	5.3	0.16	75	123	70	53	2.7	2.4	11.5	6.4	0.36	72	59	34	25

Results of Chemical Analysis of Influent and Effluent of Sprinkling Filter No. 1

1912 Date	Temp'ture Deg. C.			INFLUENT (Imhoff Tank)										EFFLUENT									
				Parts per Million										Parts per Million									
				Nitrogen as				Suspended Matter						Nitrogen as					Suspended Matter				
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen	Gross Rate	Daily Yield in Mil. Gals. per A.	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*
May 1	8	....	....	.....	.....	.....	.....	.....	.....	.....	.....	2.7	2.4	9.7	10.0	0.30	.....	65	51	32	19	....
" 3	18	16	18	10.0	8.0	0.16	92	110	77	33	.....	2.7	2.4	13.0	12.0	0.35	.....	87	45	27	18	....
" 4	17	15	17	10.0	8.0	0.14	89	102	65	37	.....	2.7	2.4	8.1	10.0	0.35	.....	82	50	39	11	....
" 11	21	15	16	9.5	7.0	0.14	73	110	47	63	.....	2.7	2.4	7.9	11.0	0.30	.....	70	54	31	23	....
" 13	11	13	15	8.7	7.0	0.14	78	104	47	57	57	2.7	2.4	8.3	9.0	0.35	.....	64	59	31	28	93
" 14	7	14	16	17.0	8.0	0.14	72	117	69	48	66	2.7	2.4	9.9	9.0	0.25	.....	53	43	29	14	56
" 15	11	15	17	10.0	8.0	0.12	83	148	68	80	.....	2.7	2.4	11.0	9.0	0.35	.....	70	46	27	19	39
" 16	15	14	17	11.0	7.8	0.12	85	131	65	66	21	2.7	2.4	7.0	9.5	0.25	.....	68	39	29	10	35
" 17	13	14	18	6.9	8.0	0.14	75	99	51	48	35	2.7	2.4	5.5	11.0	0.25	.....	98	38	19	19	45
" 18	12	15	17	7.7	8.0	0.14	69	105	63	42	28	2.7	2.4	6.9	8.0	0.25	.....	57	37	27	10	41
" 20	16	15	17	6.9	8.0	0.12	79	148	83	65	17	2.7	2.4	6.5	10.0	0.25	....	50	51	35	16	33
" 27	20	17	19	7.5	9.0	0.16	86	125	80	45	00	2.7	2.4	8.9	6.0	0.40	.....	71	131	61	70	36
" 29	22	18	20	6.1	8.0	0.16	81	96	61	35	33	2.7	2.4	8.1	6.0	0.45	.....	68	124	65	59	57
" 31	14	17	19	8.6	9.5	0.16	72	103	61	42	20	2.7	2.4	6.6	7.5	0.35	0.45	45	51	24	27	60
Average	15	15	17	9.2	8.0	0.14	80	115	64	51	31	2.7	2.4	8.4	9.1	0.32	0.45	68	58	34	24	49

*Per cent. saturation.

Results of Chemical Analysis of Influent and Effluent of Sprinkling Filter No. 1

1912 Date	Temp'ture Deg. C.			INFLUENT (Imhoff Tank) Parts per Million									EFFLUENT Parts per Million										Relative Stability	
				Nitrogen as					Suspended Matter						Nitrogen as					Matter Suspended					
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Gross Rate	Daily Yield in Mil. Gals. per A	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Straight	Dilution 1:1
June 4	21	19	18	5.9	9.0	0.12	0.34	81	105	59	46	0	2.7	2.4	8.2	7.5	0.40	0.20	64	129	60	69	47	...	...
" 5	16	19	17	7.9	7.0	0.12	1.40	70	88	57	31	0	2.7	2.4	4.1	6.0	0.25	0.30	46	54	33	21	.....	...	...
" 8	10	18	16	7.0	9.5	0.10	0.48	76	116	73	43	0	2.7	2.4	6.6	7.5	0.25	0.30	52	70	41	29	41	...	...
" 11	16	19	17	11.0	8.5	0.10	0.54	120	129	43	86	4	2.7	2.4	6.0	6.5	0.20	0.10	66	52	31	21	42	...	...
" 13	17	19	17	11.0	8.0	0.12	0.74	98	215	127	88	13	2.7	2.4	6.0	6.5	0.20	0.15	62	55	27	28	27	...	...
" 19	15	20	18	12.0	9.0	0.22	0.82	87	144	95	49	4	2.7	2.4	7.9	7.0	0.20	0.05	61	76	54	22	34	...	...
" 21	18	21	20	8.5	8.0	0.14	.....	95	193	112	81	13	2.7	2.4	6.3	7.0	0.10	....	63	42	21	21	29	...	...
" 22	15	20	20	11.0	9.0	0.16	0.73	78	204	116	88	0	2.7	2.4	5.5	7.0	0.16	0.24	69	42	25	17	39	...	...
" 25	21	21	21	11.0	9.5	0.16	0.41	102	236	145	91	0	2.7	2.4	6.0	6.5	0.23	0.22	60	83	50	33	32	...	...
" 27	24	24	23	5.7	9.5	0.16	0.38	94	162	103	59	0	2.7	2.4	5.0	7.5	0.16	0.09	53	53	33	20	26	...	...
" 29	24	22	23	11.0	10.0	0.14	0.32	87	386	213	173	0	2.6	2.1	4.5	8.0	0.36	0.14	37	67	37	30	32	10	25
Average	18	20	19	9.3	8.8	0.14	0.62	90	180	104	76	3	2.7	2.3	6.0	7.0	0.23	0.18	58	66	38	28	35	10	25

*Per cent. solution.

Results of Chemical Analysis of Influent and Settled Effluent of Sprinkling Filter No. 1

1912 Date	Temp'ture Deg. C.			INFLUENT (Imhoff Tank)									EFFLUENT												
				Parts per Million											Parts per Million									Relative Stability	
				Nitrogen as					Suspended Matter						Nitrogen as					Suspended Matter					
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Gross Rate	Daily Yield in Mil. Gals. per A.	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Fixed	Volatile	Dissolved Oxygen*	Straight	Dilution 1:1
July 7	...	23	24	7.8	9.5	0.16	0.22	48	131	77	54	0	2.6	2.1	3.7	8.0	0.60	0.55	28	36	20	16	.....	12	24
" 9	26	24	25	7.7	8.0	0.14	0.25	91	140	77	63	0	2.6	2.1	3.8	5.5	0.30	0.00	54	74	36	38	10	8	28
" 10	27	25	26	9.0	7.5	0.20	0.24	88	261	154	107	0	2.6	2.1	5.0	7.5	0.30	0.15	64	60	32	28	0	7	21
" 18	24	26	24	11.0	7.5	0.14	0.45	99	309	184	125	0	2.6	2.1	5.2	6.5	0.10	0.35	52	49	36	13	20	8	42
" 21	...	22	22	6.1	8.0	0.24	0.45	49	237	107	130	0	2.6	2.1	4.1	6.0	0.35	0.25	15	40	25	15	.....	8	23
" 23	19	25	23	9.1	9.0	0.18	0.33	121	209	116	93	0	2.6	2.1	2.8	6.5	0.15	0.00	59	55	26	29	.....	6	22
" 28	...	23	22	7.2	8.5	0.22	0.09	35	96	45	51	0	2.6	2.1	2.6	7.5	0.55	0.85	24	50	22	28	43	24	95
" 29	21	23	23	7.3	6.0	0.12	0.54	81	146	80	66	0	2.6	2.1	0.7	4.5	0.30	0.70	34	32	17	15	50	30	53
Average	23	24	24	8.1	8.0	0.18	0.32	76	191	105	86	0	2.6	2.1	3.5	6.5	0.33	0.36	41	50	27	23	25	13	38

*Per cent. saturation.

Results of Chemical Analysis of Influent and Settled Effluent of Sprinkling Filter No. 1

1912 Date	Temp'ture Deg. C.			INFLUENT (Imhoff Tank) Parts per Million								EFFLUENT												Relative Stability	
				Nitrogen as					Suspended Matter					Parts per Million											
														Nitrogen as					Suspended Matter					
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Gross Rate	Daily Yield in Mil. Gals. per A.	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Straight	Dilution 1:1
Aug. 1.....	13	23	21	9.3	8.0	0.14	0.35	109	140	80	60	2.6	2.1	1.1	5.0	0.10	0.20	60	27	16	11	25	23	30
" 5.....	18	21	19	6.4	8.5	0.14	0.16	93	120	74	46	2.6	2.1	4.6	5.5	0.25	0.25	51	42	27	15	.....	32	35
" 8.....	20	23	22	7.9	7.0	0.10	0.45	77	118	60	58	2.6	2.1	1.0	7.5	0.25	0.20	32	22	11	11	.....	32	59
" 11.....	21	21	21	7.1	7.0	0.12	0.41	31	102	27	75	2.6	2.1	1.6	6.0	0.45	0.75	20	41	9	32	.....	.....	.....
" 13.....	22	23	22	6.3	7.0	0.12	0.37	70	122	77	45	2.6	2.1	3.5	5.0	0.30	0.20	30	26	16	10	50	27	44
" 15.....	22	23	22	8.5	8.0	0.16	0.25	91	134	87	47	2.6	2.1	3.8	5.5	0.25	0.65	43	30	18	12	39	29	71
" 19.....	26	22	22	8.0	8.5	0.12	0.22	60	121	75	46	2.6	2.1	4.2	7.5	0.45	0.55	25	28	15	13	45	95	95
" 22.....	22	23	22	8.5	8.0	0.18	0.12	84	143	82	61	2.6	2.1	4.6	5.5	0.25	0.75	41	28	17	11	40	20	70
" 24.....	17	23	20	3.6	6.5	0.12	0.10	89	150	93	57	2.6	2.1	2.4	4.5	0.25	0.35	31	48	23	25	28	41	52
" 27-28....	18	22	20	6.1	8.0	0.14	0.00	84	138	55	83	2.6	2.1	5.0	5.0	0.15	0.05	43	34	13	21	29	68	95
" 29-30....	10	22	20	10.0	6.5	0.14	0.14	87	115	61	54	2.6	2.1	3.3	6.0	0.25	0.00	44	28	12	16	33	63	95
Average	19	22	21	7.4	7.5	0.13	0.23	80	127	70	57	2.6	2.1	3.2	5.7	0.27	0.36	38	32	16	16	36	43	65

*Per cent. saturation.

Results of Chemical Analysis of Influent and Settled Effluent of Sprinkling Filter No. 1

1912 Date	Temp'ture Deg. C.			INFLUENT (Imhoff Tank)									EFFLUENT											
				Parts per Million											Parts per Million									
				Nitrogen as					Suspended Matter						Nitrogen as					Suspended Matter				
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrates	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Gross Rate	Daily Yield in Mil. Gals. per A.	Organic	Free Ammonia	Nitrates	Nitrites	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Relative Stability: Straight	Relative Stability: Dilution 1:1
Sept. 3–4.....	24	23	22	9.2	6.5	0.16	0.58	82	126	68	58	0	2.6	2.1	3.5	5.0	0.40	0.10	38	28	18	10	59	95	95
" 5–6.....	26	24	24	7.7	8.0	0.20	0.25	90	104	65	39	0	2.6	2.1	4.1	6.0	0.45	0.85	38	29	15	14	42	68	83
" 9–10....	25	23	22	6.7	9.0	0.20	0.00	82	108	80	28	0	2.6	2.1	4.3	5.0	0.30	0.10	36	37	25	12	34	95	95
" 12–13....	15	23	21	9.1	9.0	0.18	0.23	86	119	78	41	0	2.6	2.1	3.6	6.5	0.25	0.00	36	37	26	11	30	45	80
Average	23	23	22	8.2	8.1	0.18	0.26	85	114	73	41	0	2.6	2.1	3.9	5.6	0.35	0.26	37	33	21	12	41	76	88

*Per cent. saturation.

APPENDIX H

Detailed Results of Analyses of Influent and Effluent of Sprinkling Filter No. 2

Results of Chemical Analysis of Influent and Effluent of Sprinkling Filter No. 2

1912 Date	Temp'ture Deg. C.			INFLUENT (Dortmund Tank)								EFFLUENT									
				Parts per Million										Parts per Million							
				Nitrogen as				Matter Suspended						Nitrogen as					Matter Suspended			
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Gross Rate	Daily Yield in Mil. Gals. per A.	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*
May 27....	20	17	15	6.7	9.0	0.14	82	100	63	37	0	2.7	2.3	8.2	7.5	0.25	.....	66	63	29	34	33
" 29....	22	18	17	7.9	7.0	0.10	78	104	63	41	23	2.7	2.3	6.8	6.5	0.20	.....	67	60	41	19	52
" 31....	14	17	16	8.9	9.0	0.16	69	98	58	40	16	2.7	2.3	7.6	6.5	0.20	0.60	52	35	20	15	40
Average ...	19	17	16	7.8	8.3	0.13	76	100	61	39	13	2.7	2.3	7.5	6.8	0.22	0.60	62	53	30	23	42

*Per cent. saturation.

Results of Chemical Analysis of Influent and Effluent of Sprinkling Filter No. 2

1912 Date	Temp'ture Deg. C.			INFLUENT (Dortmund Tank) Parts per Million									EFFLUENT		Parts per Million									Relative Stability	
				Nitrogen as					Suspended Matter						Nitrogen as					Suspended Matter					
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Gross Rate	Daily Yield in Mil. Gals. per A.	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Straight	Dilution 1:1
June 4	21	19	19	5.9	9.0	0.10	0.48	79	122	71	51	0	2.7	2.3	7.1	7.0	0.25	0.10	56	96	36	60	45	...	...
" 5	16	19	17	6.6	7.5	0.12	0.64	69	100	68	32	0	2.7	2.3	5.4	5.5	0.15	0.10	50	73	34	39	.....	...	...
" 8	10	18	16	9.1	9.0	0.10	0.45	76	106	67	39	0	2.7	2.3	5.8	7.0	0.20	0.25	54	70	33	37	57	...	...
" 11	16	19	17	6.7	9.0	0.10	0.46	112	141	84	57	0	2.7	2.3	6.5	6.0	0.25	0.20	74	95	36	59	40	...	...
" 13	17	19	18	8.8	8.5	0.14	0.57	90	139	79	60	8	2.7	2.3	5.7	6.0	0.15	0.30	61	79	43	36	32	...	...
" 19	15	20	18	3.5	9.0	0.20	0.69	82	128	86	42	2	2.7	2.3	16.7	7.0	0.30	0.00	70	170	102	68	47	...	...
" 21	18	21	20	5.3	8.0	0.14	.....	90	118	68	50	11	2.7	2.3	8.1	6.0	0.15	....	62	79	27	52	30	...	...
" 22	15	21	20	11.0	9.5	0.14	0.74	75	107	65	42	0	2.7	2.3	5.4	5.5	0.26	0.29	50	62	31	31	48	...	...
" 25	21	21	21	7.0	9.5	0.14	0.47	91	127	83	44	0	2.7	2.3	6.5	6.0	0.20	0.45	57	99	52	47	37	...	...
" 27	24	23	23	7.5	9.0	0.12	0.29	88	162	103	59	0	2.4	2.0	1.9	9.0	0.20	0.10	50	70	37	33	30	...	...
" 29	24	23	23	7.0	9.5	0.10	0.10	100	79	46	33	0	2.4	2.0	4.7	7.0	0.36	0.19	36	56	24	32	44	25	55
Average	18	20	19	7.1	8.9	0.13	0.49	87	121	75	46	2	2.6	2.2	6.7	6.5	0.22	0.20	56	86	41	45	41	25	55

*Per cent. saturation.

Results of Chemical Analysis of Influent and Settled Effluent of Sprinkling Filter No. 2

1912 Date	Temp'ture Deg. C.			INFLUENT (Dortmund Tank)										EFFLUENT											
				Parts per Million												Parts per Million									
				Nitrogen as					Suspended Matter							Nitrogen as					Suspended Matter				Relative Stability	
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen	Gross Rate	Daily Yield in Mil. Gals. per A.	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Straight	Dilution 1:1
July 7	...	23	24	8.3	9.0	0.20	0.17	41	98	58	40	0	2.4	2.0	3.9	7.0	1.05	0.00	28	39	19	20	.....	25	57
" 9	26	24	25	8.5	8.0	0.22	0.19	89	163	90	73	0	2.4	2.0	4.6	5.5	0.45	0.05	50	57	25	32	20	15	35
" 10	27	25	26	9.0	7.5	0.22	0.18	85	172	100	72	0	2.4	2.0	4.6	5.6	0.45	0.10	49	47	21	26	16	18	36
" 18	24	26	24	11.0	7.0	0.16	0.27	100	264	153	111	0	2.4	2.0	4.0	8.5	0.20	0.10	52	49	32	17	26	18	39
" 21	...	22	22	7.4	7.5	0.24	0.59	48	240	112	128	0	2.4	2.0	3.7	8.0	0.55	0.65	28	53	28	25	.....	30	39
" 23	19	23	23	9.1	9.0	0.14	0.40	122	210	106	104	0	2.4	2.0	3.0	9.5	0.15	0.05	62	75	39	36	.....	10	31
" 28	...	23	22	7.2	8.5	0.26	0.16	41	195	91	104	0	2.4	2.0	4.5	8.0	1.05	2.30	28	64	30	34	52	95	95
" 29	21	23	23	15.0	6.5	0.12	0.56	90	209	102	107	0	2.4	2.0	4.8	4.5	0.45	0.80	47	36	16	20	45	35	50
Average	23	24	24	9.4	7.8	0.20	0.32	77	194	102	92	0	2.4	2.0	4.1	7.1	0.54	0.51	43	53	26	27	32	31	48

*Per cent. saturation.

Results of Chemical Analysis of Influent and Settled Effluent of Sprinkling Filter No. 2

1912 Date	Temperature Deg. C.			INFLUENT (Dortmund Tank)								EFFLUENT												
				Parts per Million										Parts per Million									Relative Stability	
				Nitrogen as					Suspended Matter					Nitrogen as					Suspended Matter					
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Gross Rate	Daily Yield in Mil. Gals. per A.	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Straight	Dilution 1:1
Aug. 1.....	13	23	21	6.1	8.0	0.14	0.30	116	209	105	104	2.4	2.0	3.7	4.0	0.20	0.10	62	34	18	16	27	9	52
" 5.....	18	21	19	7.7	8.0	0.12	0.36	99	164	82	82	2.4	2.0	3.5	5.0	0.35	0.45	51	33	21	12	.....	45	95
" 8.....	20	22	22	11.0	7.5	0.12	0.36	86	217	101	116	2.4	2.0	2.0	6.5	0.25	0.35	33	34	21	13	.....	30	80
" 11.....	21	21	21	10.0	7.0	0.14	0.31	52	281	93	188	2.4	2.0	5.4	5.5	0.45	0.55	34	116	42	74	.....	.....	.....
" 13.....	22	23	22	11.0	6.5	0.18	0.25	82	246	111	135	2.4	2.0	3.7	4.0	0.25	0.55	35	43	22	21	45	36	72
" 15.....	22	23	22	10.0	8.0	0.20	0.24	98	163	25	138	2.4	2.0	4.5	5.5	0.35	0.55	45	43	20	23	36	38	65
" 19.....	26	22	23	9.1	9.0	0.18	0.15	75	249	120	129	2.4	2.0	3.9	7.0	0.70	1.00	29	37	18	19	53	95	95
" 22.....	22	23	22	9.3	8.0	0.14	0.14	85	236	110	126	2.4	2.0	5.6	4.5	0.30	0.90	41	44	22	22	18	28	42
" 24.....	17	23	20	5.8	7.5	0.22	0.00	76	278	129	149	2.4	2.0	3.4	3.5	0.55	0.05	31	48	23	25	33	47	95
" 27–28..	18	22	22	9.3	8.0	0.20	0.00	91	282	112	170	2.4	2.0	4.3	5.0	0.25	0.05	43	48	18	30	33	88	95
" 29–30..	10	22	20	9.6	8.5	0.20	0.12	94	306	135	171	2.4	2.0	3.5	5.0	0.35	0.00	41	33	15	18	34	64	84
Average ...	19	22	21	9.0	7.8	0.17	0.20	87	239	102	137	2.4	2.0	4.0	5.0	0.36	0.41	40	47	22	25	35	48	78

*Per cent. saturation.

Results of Chemical Analysis of Influent and Settled Effluent of Sprinkling Filter No. 2

1912 Date	Temp'ture Deg. C.			INFLUENT (Dortmund Tank) Parts per Million								EFFLUENT												
				Nitrogen as					Suspended Matter					Parts per Million									Relative Stability	
														Nitrogen as					Suspended Matter					
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Gross Rate	Daily Yield in Mil. Gals. per A	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Straight	Dilution 1:1
Sept. 3–4...	24	23	22	11.0	7.5	0.38	0.58	87	254	115	139	2.4	2.0	4.0	4.5	0.65	.....	34	31	16	15	57	95	95
" 5–6...	26	24	24	8.3	9.0	0.12	0.16	96	246	120	126	2.4	2.0	2.2	5.5	0.40	0.00	37	31	17	14	49	73	95
" 9–10..	25	23	23	8.6	9.5	0.24	0.00	90	304	171	133	2.4	2.0	5.1	5.0	0.55	0.35	34	34	25	9	41	95	95
" 12–13..	15	23	21	13.0	9.5	0.26	0.34	91	333	185	148	2.4	2.0	2.2	5.5	0.40	0.40	51	31	19	12	41	65	73
Average ...	23	23	23	10.2	8.9	0.25	0.27	91	284	148	136	2.4	2.0	3.4	5.1	0.50	0.25	39	32	19	13	47	82	90

*Per cent. saturation.

APPENDIX I

Detailed Results of Analyses of Influent and Effluent of Sprinkling Filter No. 3

Results of Chemical Analysis of Influent and Effluent of Sprinkling Filter No. 3

1912 Date	Temperature Deg. C.			INFLUENT (Imhoff Tank)								EFFLUENT										
				Parts per Million										Parts per Million								
				Nitrogen as				Suspended Matter						Nitrogen as					Suspended Matter			
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Gross Rate	Daily Yield in Mil. Gals. per A.	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*
May 27.....	20	17	16	7.5	9.0	0.16	86	125	80	45	0	2.7	2.3	8.5	8.0	0.25	.....	70	78	41	37	27
" 29.....	22	18	17	6.1	8.0	0.16	81	96	61	35	33	2.7	2.3	7.8	5.5	0.20	.....	66	55	34	21	50
" 31.....	14	17	16	8.6	9.5	0.16	72	103	61	42	20	2.7	2.3	6.6	7.5	0.20	0.60	50	31	17	14	43
Average	19	17	16	7.4	8.8	0.16	80	108	67	41	18	2.7	2.3	7.6	7.0	0.22	0.60	62	55	31	24	40

*Per cent. saturation.

Results of Chemical Analysis of Influent and Effluent of Sprinkling Filter No. 3

1912 Date	Temp'ture Deg. C.			INFLUENT (Imhoff Tank)									EFFLUENT												
				Parts per Million											Parts per Million									Relative Stability	
				Nitrogen as					Suspended Matter						Nitrogen as					Suspended Matter					
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Gross Rate	Daily Yield in Mil. Gals. per A.	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Straight	Dilution 1:1
June 4.....	21	19	19	5.9	9.0	0.12	0.34	81	105	59	46	0	2.7	2.3	7.4	7.5	0.15	0.05	61	82	33	49	.....	...	...
" 5.....	16	19	18	7.9	7.0	0.12	1.40	70	88	57	31	0	2.7	2.3	7.0	5.5	0.15	0.10	49	49	20	29	.....	...	...
" 8.....	10	18	15	7.0	9.5	0.10	0.48	76	116	73	43	0	2.7	2.3	3.9	7.0	0.25	0.05	48	34	17	17	42	...	...
" 11.....	16	19	17	11.0	8.5	0.10	0.54	120	129	43	86	4	2.7	2.3	6.8	6.5	0.20	0.15	72	75	39	36	36	...	...
" 13.....	17	19	18	11.0	8.0	0.12	0.74	98	215	127	88	13	2.7	2.3	6.0	6.5	0.30	0.15	61	84	38	46	37	...	...
" 19.....	15	20	18	12.0	9.0	0.22	0.82	87	144	95	49	4	2.7	2.3	9.0	7.5	0.20	0.00	59	107	63	44	36	...	...
" 21.....	18	21	20	8.5	8.0	0.14	.....	95	193	112	81	13	2.7	2.3	3.6	6.5	0.25	....	68	53	25	28	32	...	...
" 22.....	15	21	20	11.0	9.0	0.16	0.73	78	204	116	88	0	2.7	2.3	5.2	6.5	0.26	0.24	44	43	21	22	42	...	...
" 25.....	21	21	21	11.0	9.5	0.16	0.41	102	236	145	91	0	2.7	2.3	2.8	6.5	0.16	0.34	57	54	31	23	33	...	...
" 27.....	24	24	23	5.7	9.5	0.16	0.38	94	162	103	59	0	2.4	2.0	5.2	6.5	0.20	0.10	52	104	45	59	34	...	...
" 29.....	24	22	23	11.0	10.0	0.14	0.32	87	386	213	173	0	2.4	2.0	5.8	7.5	0.36	0.19	48	177	63	114	32	8	25
Average	18	20	19	9.3	8.8	0.14	0.62	90	180	104	76	3	2.6	2.2	5.7	6.7	0.23	0.14	56	78	36	42	36	8	25

*Per cent. saturation.

Results of Chemical Analysis of Influent and Settled Effluent of Sprinkling Filter No. 3

1912 Date	Temp'ture Deg. C.			INFLUENT (Imhoff Tank)										EFFLUENT												
				Parts per Million												Parts per Million									Relative Stability	
				Nitrogen as					Matter Suspended							Nitrogen as					Suspended Matter					
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*		Gross Rate	Daily Yield in Mil. Gals. per A.	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Straight	Dilution 1:1
July 7.....	...	23	23	7.8	9.5	0.16	0.22	48	131	77	54	0		2.4	2.0	4.1	6.0	0.95	0.55	25	36	17	19	.....	18	60
" 9.....	26	24	24	7.7	8.0	0.14	0.25	91	140	77	63	0		2.4	2.0	5.1	5.0	0.45	0.00	45	46	20	26	26	40	43
" 10.....	27	25	26	9.0	7.5	0.20	0.24	88	261	154	107	0		2.4	2.0	3.0	5.5	0.45	0.20	46	47	30	17	18	25	32
" 18.....	24	26	24	11.0	7.5	0.14	0.45	99	309	184	125	0		2.4	2.0	4.7	7.0	0.20	0.15	48	39	24	15	28	12	35
" 21.....	...	22	22	6.1	8.0	0.24	0.45	49	237	107	130	0		2.4	2.0	5.4	5.5	0.70	0.55	26	54	29	25	.....	29	35
" 23.....	19	25	23	9.1	9.0	0.18	0.33	121	209	116	93	0		2.4	2.0	4.9	6.0	0.20	0.05	58	53	27	26	.....	28	31
" 28.....	...	23	22	7.2	8.5	0.22	0.09	35	96	45	51	0		2.4	2.0	3.6	6.5	1.05	2.25	24	48	22	26	50	95	95
" 29.....	21	23	23	7.3	6.0	0.12	0.54	81	146	80	66	0		2.4	2.0	2.2	4.5	0.60	0.90	52	43	17	26	47	65	95
Average	23	24	24	8.1	8.0	0.18	0.32	78	191	105	86	0		2.4	2.0	4.1	5.8	0.58	0.58	41	46	23	23	32	39	53

*Per cent. saturation.

Results of Chemical Analysis of Influent and Settled Effluent of Sprinkling Filter No. 3

1912 Date	Temp'ture Deg. C.			INFLUENT (Imhoff Tank) Parts per Million								EFFLUENT										Relative Stability	
				Nitrogen as					Suspended Matter					Parts per Million									
														Nitrogen as					Suspended Matter				
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Gross Rate	Daily Yield in Mil. Gals. per A.	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Straight	Dilution 1:1
Aug. 1.....	13	23	21	9.3	8.0	0.14	0.35	109	140	80	60	2.4	2.0	3.7	4.0	0.15	0.00	55	24	14	10	25	55	55
" 5.....	18	21	19	6.4	8.5	0.14	0.16	93	120	74	46	2.4	2.0	3.5	5.0	0.40	0.60	44	28	18	10	.....	80	95
" 8.....	20	23	22	7.9	7.0	0.10	0.45	77	118	60	58	2.4	2.0	2.7	5.0	0.35	1.55	32	29	15	14	.....	50	78
" 11.....	21	21	21	7.1	7.0	0.12	0.41	31	102	27	75	2.4	2.0	2.7	5.0	0.60	0.80	19	47	6	41	.....	.....	.....
" 13.....	22	23	22	6.3	7.0	0.12	0.37	70	122	77	45	2.4	2.0	2.9	4.0	0.35	0.65	28	18	12	6	56	95	95
" 15.....	22	23	22	8.5	8.0	0.16	0.25	91	134	87	47	2.4	2.0	3.0	5.5	0.40	0.70	39	31	15	16	45	65	95
" 19.....	26	22	23	8.0	8.5	0.12	0.22	60	121	75	46	2.4	2.0	3.6	6.5	0.65	0.85	26	32	17	15	51	75	95
" 22.....	22	23	22	8.5	8.0	0.18	0.12	84	143	82	61	2.4	2.0	5.1	5.0	0.40	0.90	39	36	18	18	40	64	80
" 24.....	17	23	20	3.6	6.5	0.12	0.10	89	150	93	57	2.4	2.0	3.1	3.0	0.50	0.80	36	25	13	12	41	64	95
" 27–28..	18	22	20	6.1	8.0	0.14	0.00	84	138	55	83	2.4	2.0	1.3	4.0	0.25	0.45	39	37	15	22	40	95	95
" 29–30..	10	22	20	10.0	6.5	0.14	0.14	87	115	61	54	2.4	2.0	3.5	5.0	0.40	0.20	42	32	16	16	48	82	95
Average	19	22	21	7.4	7.5	0.13	0.23	80	128	70	58	2.4	2.0	3.2	4.7	0.40	0.68	36	31	14	17	43	73	88

*Per cent. saturation.

Results of Chemical Analysis of Influent and Settled Effluent of Sprinkling Filter No. 3

1912 Date	Temp'ture Deg. C.			INFLUENT (Imhoff Tank)								EFFLUENT											
				Parts per Million										Parts per Million								Relative Stability		
				Nitrogen as					Suspended Matter					Nitrogen as					Suspended Matter					
	Air	Influent	Effluent	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Gross Rate	Daily Yield in Mil. Gals. per A.	Organic	Free Ammonia	Nitrites	Nitrates	Oxygen Consumed	Total	Volatile	Fixed	Dissolved Oxygen*	Straight	Dilution 1:1	Dilution 1:2
Sept. 3–4....	24	23	23	9.2	6.5	0.16	0.58	82	126	68	58	2.4	2.0	3.7	4.5	0.60	0.00	36	26	22	4	63	95	95	...
" 5–6....	26	24	24	7.7	8.0	0.20	0.25	90	104	65	39	2.4	2.0	2.7	5.0	0.45	0.00	38	22	13	9	46	64	84	...
" 9–10...	25	23	22	6.7	9.0	0.20	0.00	82	108	80	28	2.4	2.0	4.3	5.0	0.45	0.45	36	22	14	8	36	95	95	95
" 12–13...	15	23	21	9.1	9.0	0.18	0.23	86	119	78	41	2.4	2.0	3.6	6.5	0.40	0.50	35	34	26	8	34	66	95	95
Average	23	23	23	8.2	8.1	0.19	0.27	85	114	73	41	2.4	2.0	3.6	5.2	0.47	0.24	36	26	19	7	45	80	92	95

*Per cent. saturation.

APPENDIX J

Device for Measuring Supernatant Liquid Over Sludge

SLUDGE MEASURING DEVICE

The device shown in Appendix J is used for measuring the supernatant liquid over the sludge deposited in a tank. It has been used in experimental work for the last four years and has given very accurate results where the accumulation of sludge over a definite period of time is desired.

It consists of a graduated rod with a wide mouth bottle attached to one end and the zero on the scale level with the top of the bottle. A small copper wire is fastened into a rubber stopper and extends through eyes to the top of the rod. A rod 10 feet long is convenient for measuring depths 9 feet or less and for greater depths the extension as shown in sketch has given good results.

In taking measurements the stopper is inserted in the bottle and the rod lowered into the supernatant liquid by depths of 1 foot until the sludge layer is located. A new location is then taken and the bottle lowered 0.1 foot or a fraction on each successive trial, depending upon the accuracy desired, until the sludge layer is reached. The sludge deposited in a tank is ordinarily found in a compact mass and the contents of the bottle brought up at each measurement will represent the contents of the tank at any given depth. This was demonstrated very clearly during the tests at Gloversville, N. Y., where a settling tank 8 feet (working capacity) was built with a glass window in the side and measurements taken opposite the window. A series of tests were made with the above device in the hands of a filter attendant and the accuracy of the results warranted its adoption for all future work.

If very accurate results are desired two men are required, one to hold the rod and pull out the stopper and the other to record the reading of the surface of the water on the scale. When the sludge is in a stage of active fermentation the contents of the bottle will show black suspended particles, but the true sludge will be apparent as soon as the bottle has been lowered so that the sludge can flow into the bottle.

In computing the volume of sludge in a given tank, the depth of the supernatant liquid over the sludge is deducted from the total working depth of the tank.

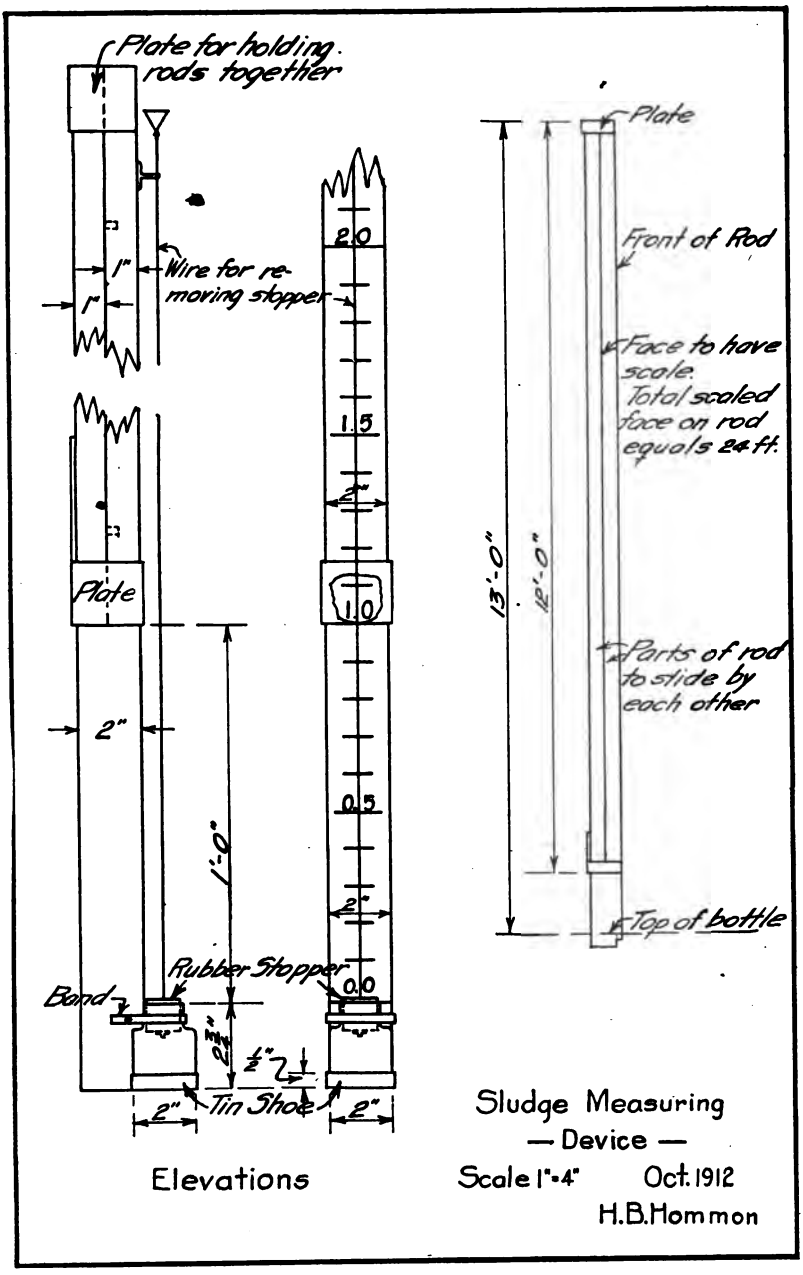
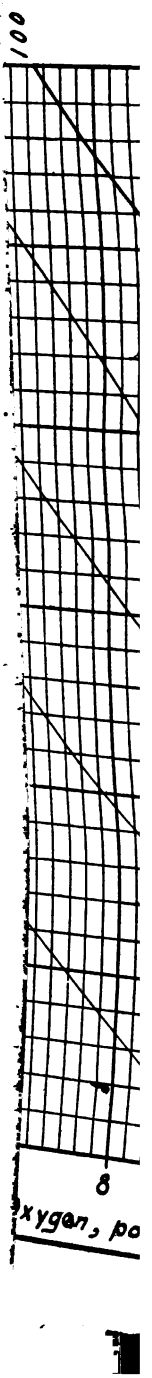


Plate for holding rods together
1"
1"
Wire for removing stopper
2.0
1.5
1.0
0.5
0.0
Plate
2"
1'-0"
Rubber Stopper
Band
2½"
½"
2"
Tin Shoe
2"
Elevations
Plate
Front of Rod
Face to have scale. Total scaled face on rod equals 24 ft.
13'-0"
12'-0"
Parts of rod to slide by each other
Top of bottle
Sludge Measuring
— Device —
Scale 1"=4" Oct. 1912
H.B. Hommon

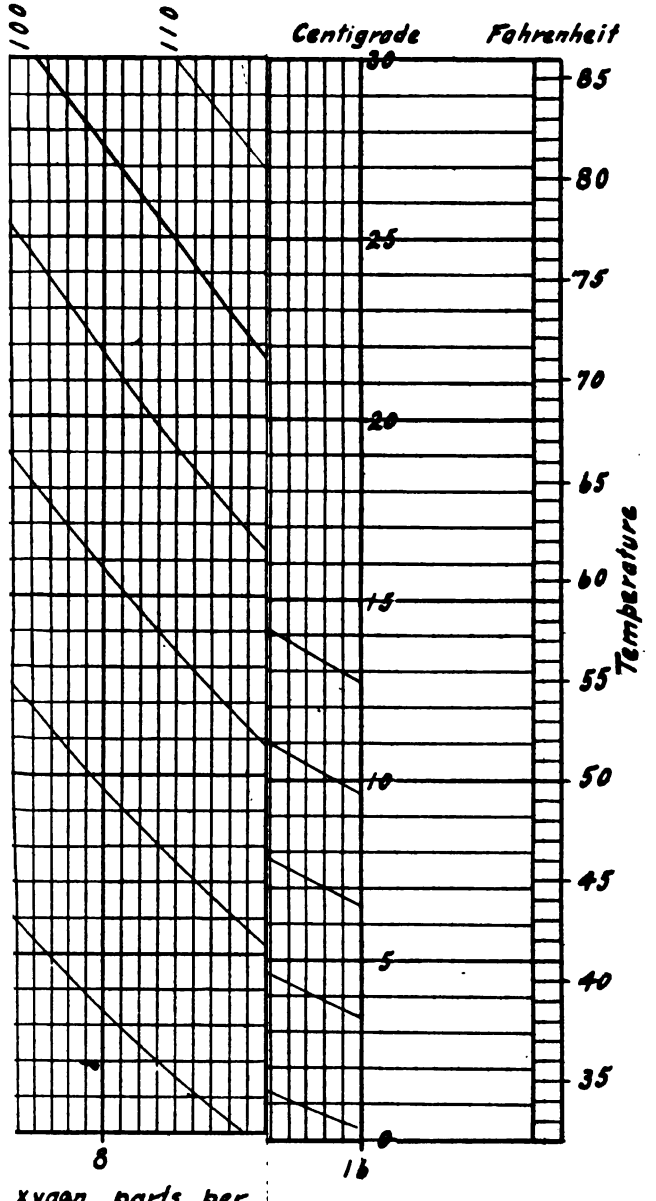
APPENDIX K

Curve Plotted to Show Per Cent. Saturation and Parts per Million of Dissolved Oxygen in Water of Various Temperatures on the Fahrenheit and Centigrade Scale

Air in



Air in terms


100
10
Centigrade
Fahrenheit
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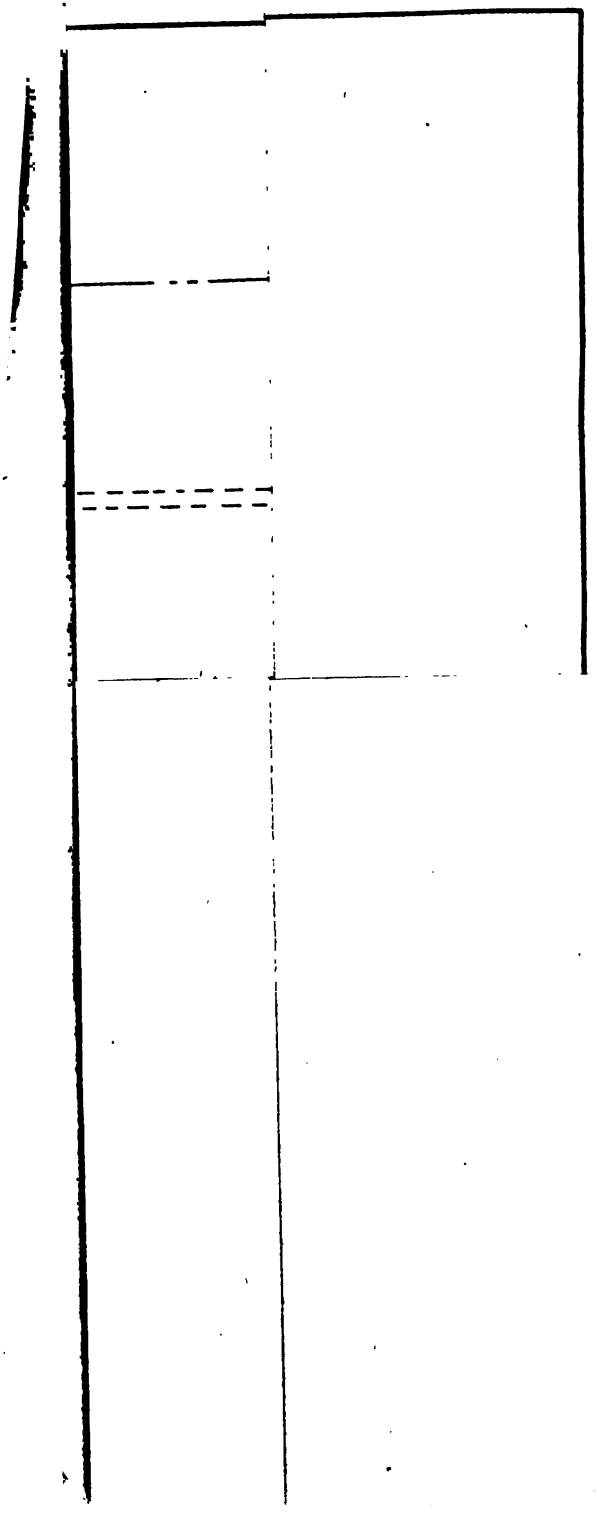
20
15
10
5
0
85
80
75
70
65
60
55
50
45
40
35
Temperature
8
16
xygen, parts per



ge
5
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9

3
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17
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6
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9
3
4
5
3

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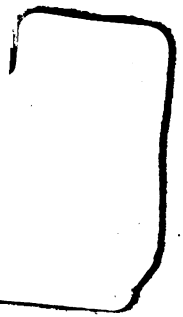

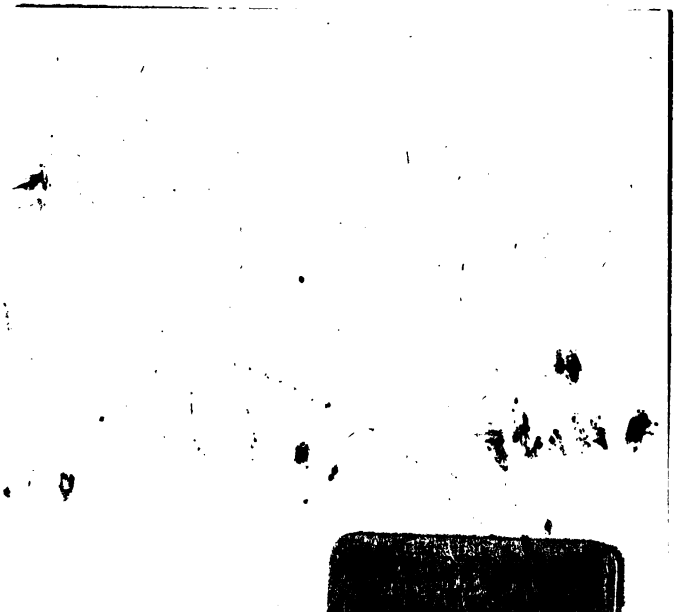

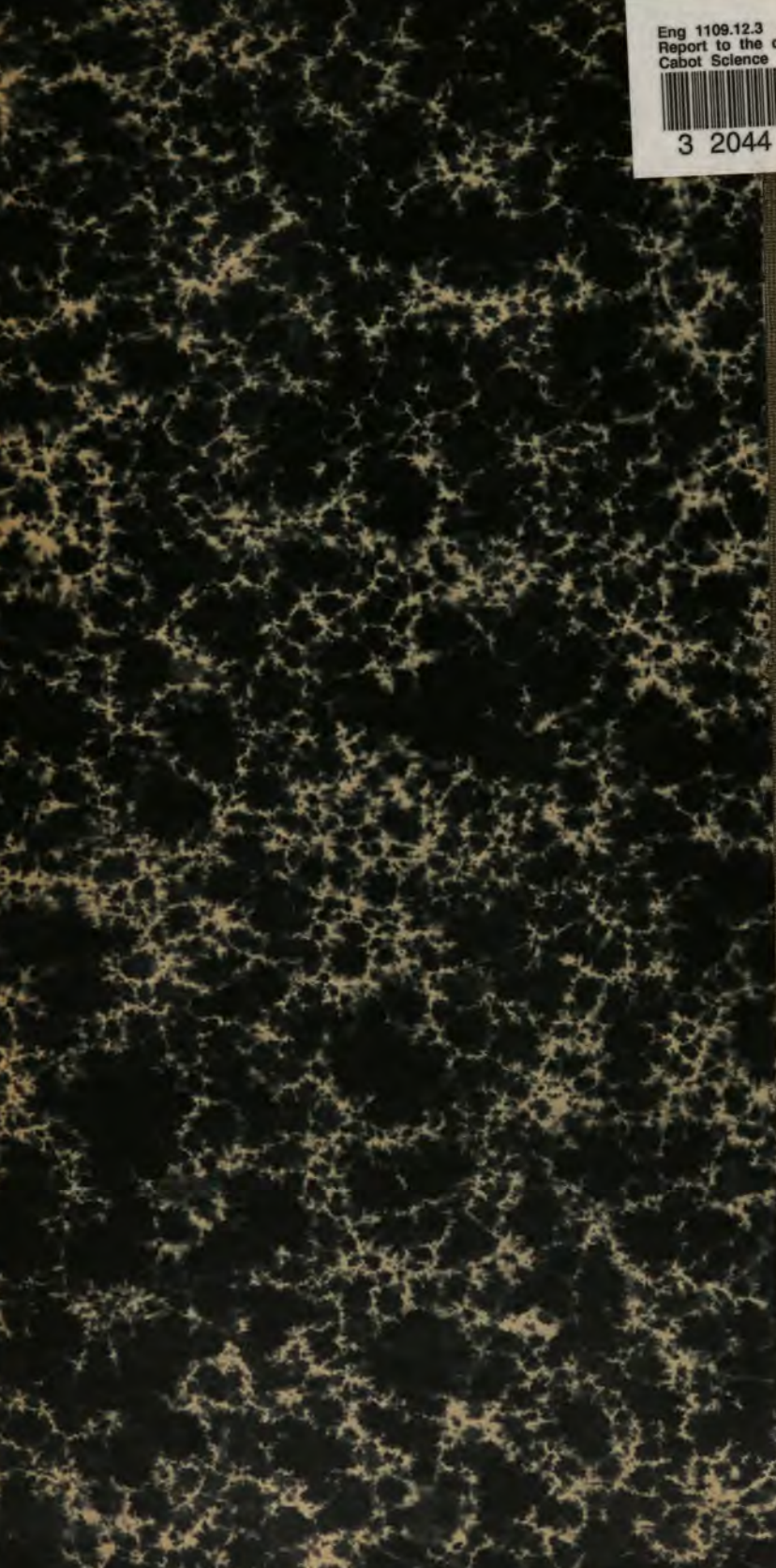

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